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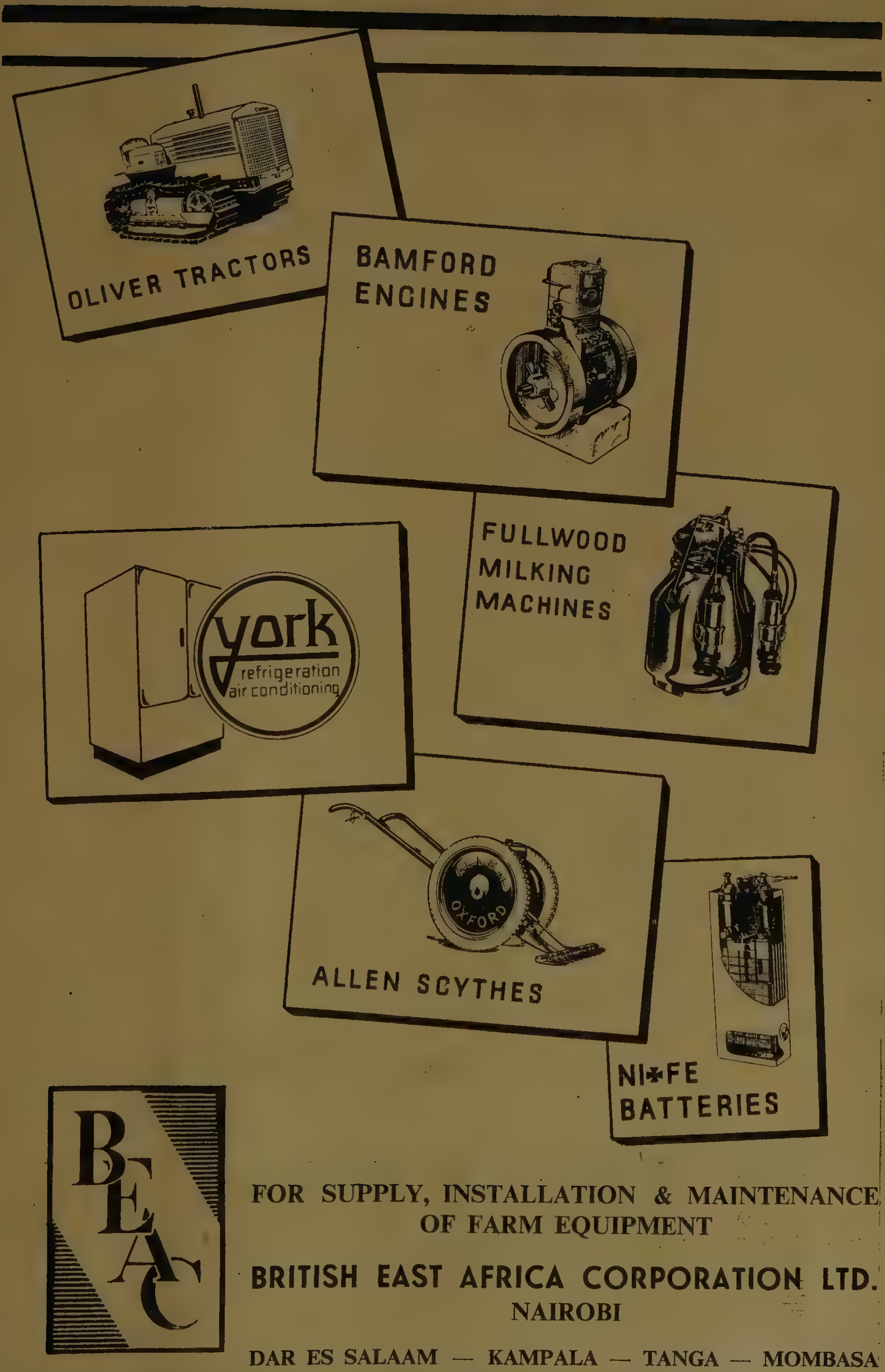

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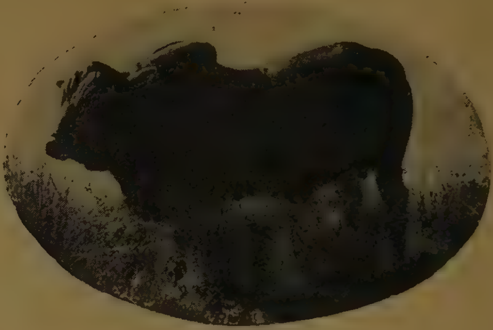

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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THE LIMITATIONS OF BIOLOGICAL CONTROL OF THE SISAL WEEVIL

By Wendell F. Sellers, Assistant Director, Commonwealth Bureau of Biological Control, Fontana Laboratory, Fontana, California

(*Received for publication on 22nd January,* 1951)

In 1945, the Colonial Office approached the Commonwealth Bureau of Biological Control for advice concerning the use of natural enemies for the control of the sisal weevil as a pest of the sisal plantations in East Africa. Dr. W. R. Thompson, Director of the Bureau, made inquiry as to the possibility of securing the desired information in the south-western United States.

There is no precedent that the biological control method would be useful for controlling the sisal weevil. The use and artificial production of *Agave* fibres goes back into antiquity, and the sisal weevil has always been a more or less troublesome pest. One of the more primitive methods of artificial control is the reaming of the weevil burrows with sharp-pointed sticks. Insect enemies are unknown or unrecorded. Although the situation is not hopeless, it is far from being promising of worthwhile results.

Scyphophorus acupunctatus Gyll. is a Curculionid beetle belonging to the sub-family Calandrinæ. Its nearest relative is *Scyphophorus yuccæ* Horn. Some authorities suspect them to be the same species with two races showing host plant preferences. *Scyphophorus acupunctatus* feeds on the various species of *Agave* or century plants. The literature consulted indicates that the sisal weevil has been recorded on *Agave fourcroydes*; *A. sisalana*; *A. mexicana; A. americana* var. *variegata; A. amaniensis; A. ingens; A. frankeera; A. vivipara;* and *Furcræa gigantea* (Mauritius hemp). There is evidently a considerable range of preference or varietal susceptibility to weevil injury. In its native habitat, the sisal weevil is more common on henequen, *A. fourcroydes* Lamaire, than it is on sisal, *A. sisalana.* In Tanganyika the weevil severely attacked *F. gigantea* in an area where injury to *A. sisalana* was negligible.

There are fully 300 species of *Agave* (more than 325 have been described), largely from the Mexican table-lands. The incidence of beetle infestation and injury is closely correlated with the presence of *Agave.* This information indicates that the native home of the *Agave* spp. and the sisal weevil is Mexico. The known habitat of the sisal weevil ranges from Central America into the south-western United States where it is recorded from California, Colorado, Arizona, New Mexico, and Texas. Elsewhere its distribution has tended to follow the development of *Agave* plantations or plantings. This circumstance extends its known distribution to the West Indies (Jamaica, Haiti, Cuba, Curaçao), East Africa (Kenya, Tanganyika), Hawaii, Java, and Sumatra.

The literature consulted did not mention any insect enemies of the sisal weevil. H. A. Ballou has suggested that it is possible that some parasite might be found in Mexico or Central America that could be utilized with advantage in localities where the weevil has been introduced. As near as can be ascertained, there is no basis for this suggestion. The possibility of securing the desired information in the south-western United States is not promising; none of the fibre-producing species of *Agave,* including sisal and henequen, is grown in this area. As the indigenous *Agave* spp. are rare, the sisal weevil is not readily encountered.

The Director General of the Mexican Department of Agriculture, Ing. Dario L. Arrieta M., states in correspondence: "On the various occasions in which the Delegaciones Fitosanitarias, working in zones in which the so-called 'Max of the Henequen' *Scyphophorus acupunctatus* Gyll. is found, have tried to determine the presence of parasites and predators of that insect, they have not obtained satisfactory results".

Dr. W. D. Pierce of the Los Angeles Museum, who is an authority on Curculionids, did not know of any insect enemies of the sisal weevil, but he considered it extremely unlikely that it would be without its parasitic enemies. He pointed out that in the past, detailed investigations on little-known Curculionids usually resulted in obtaining their parasites. He also suggested using some of the natural enemies of the cactus weevil on the sisal weevil. Very little, if anything, is known about the natural enemies of the cactus weevil, but they are certainly worth investigating.

Consideration of what is known about the parasitic enemies of Curculionid beetles of the sub-family Calandrinæ indicates that special attention should be given to the possibility of attack by Mymarids, Braconids, Tachinids, Ichneumonids, Pteromalids, and Bethylids.

Observations.

In the south-western United States indigenous *Agave* spp. are rare, but there are a few species growing wild that are available for examination. Otherwise, the *Agave* consist mostly of exotic planted species as ornamentals in botanical gardens, nurseries, and around private homes. *Agave shawii* occurs along the western coastal areas of northern Lower California (Baja California, Mexico), but the species is now extinct in California north of the Mexican border. *Agave deserti* occurs on the escarpment of the San Jacinto Mountains near Palm Springs and in the San Diego Mountains between El Centro and San Diego. Both of these places border on the western side of the Colorado Desert that extends down into Lower California. Below Claypool Tunnel on the escarpment north-east of Phœnix, Arizona, another native *Agave*, possibly *utahensis* or a variety of it, grows wild. *Agave americana* has been used for roadside landscaping in Texas and New Mexico, and this species seems to be more plentiful in the vicinity of Benson, Arizona, where some plants were noted growing in fields adjacent to the highways.

In February, 1946, ten days were spent in the vicinity of Ensenada, Baja California. A number of *Agave shawii* plants were examined. Each of two of the more heavily infested plants had beetle populations of from 40–50 adults and larvæ in various stages of development. As the plant development was not very active, the adult beetles and larvæ were relatively inactive within the bole portion of plants, the flowering poles of which were well past their prime. No information was obtained concerning parasites. As there are at least 14 species of *Agave* indigenous to Lower California, an attempt was made to locate *Agave* south and east of Ensenada, but primitive road conditions south of Santo Tomas made it impracticable to proceed further without an equipped expedition. An attempt to reach the Colorado Desert east of Ensenada was unsuccessful, because of primitive conditions, but Ojos Negros, about 20 miles from the desert, was reached.

In March, roadside scouting in the San Diego Mountains from San Diego to El Centro, and in the San Jacinto Mountains from San Jacinto to Palm Springs indicated that the flowering stalks of *Agave deserti* had not opened. In June, a return trip was made from San Jacinto to Palm Springs along the Pines-Palms highway. At an elevation of 4,500 feet on Santa Rosa Mountain in the San Bernardino National Forest, on the escarpment above Palm Springs, two weevils were collected on *Agave deserti*. One was ovipositing in a small injured area, which had the appearance of having been previously chewed by the beetle, at the base of the flower pole. The injured area was partially hidden by the upper leaves of the plant. Five eggs were collected, and the location of these indicated that they would be accessible to attack by parasites. The elevation at this point was nearly the upper limit of *Agave deserti*. On descending into Palm Springs, *A. deserti* was found growing somewhat below 1,000 feet. The species appeared to be more plentiful between 2,000–3,000 feet. At the lower elevation the flowering stalks were past their prime.

In July and August, 1946, on a trip to Mexico to collect the cactus weevil, *Cactophagus spinolæ* (Gyll.), miscellaneous observations were made on *Agave americana* in Arizona, New Mexico, and Texas, and on *Agave utahensis* below Claypool Tunnel on the escarpment north-east of Phœnix, Arizona.

While the plateau around Mexico City was being explored for the cactus weevil, a watch was maintained for *Agave* plantations. *Agave atroviens* (or *mexicana*) is grown extensively in plantings around Mexico City. It is used for making pulque and mescal, both of which are intoxicating drinks. The large leaves are used secondarily for fibre. The centre of the maturing *Agave* plant is manipulated to obtain the fermenting juices, with the result that it is prevented from producing a flowering stalk. Several injured plants were examined; on one occasion two full-grown sisal weevil larvæ were obtained, and other evidence of their presence was observed.

The work and observations outlined above were limited by the pressure of other work, the scarcity of accessible places where observations could be made, and the small amount of money available.

Conclusions.

The lack of previous observations on natural enemies and other basic difficulties inherent in the work served only to confirm the impression that the south-western area of the

United States and northern Mexico is not suitable for primary or basic investigations on the natural enemies of the sisal weevil. The sisal weevil and any natural enemies which it may have, however, could be investigated to better advantage on the Yucatan Peninsula. The State of Yucatan, which is the centre of the hemp industry, is located in the extreme south-east corner of Mexico. *Scyphophorus acupunctata* is reported as a pest of the sisal and henequen plantations there and is more common on henequen (*Agave fourcroydes* Lamaire) than on sisal.

In Mexico, about 440,000 acres of henequen are cultivated in the States of Yucatan and Campeche, and about 5,000 elsewhere. Sisal is cultivated to a limited extent in Campeche and some parts of the State of Yucatan, but the region where most of the henequen is grown is generally too dry for sisal. Both henequen and sisal are originally indigenous to the Yucatan Peninsula.

Director General, Ing. Dario L. Arrieta M., recommends that work on the natural enemies of the weevil should be carried out in the States of Tamaulipas and Yucatan because of their sisal industry.

A primary study of this problem, preferably in the Yucatan Peninsula, could be undertaken to determine if there is a basis for attempting the use of the biological control method on the sisal weevil. The preliminary investigation already conducted indicates that the problem is a complex one that will not be solved until adequate funds are available for a more extensive survey and considerable time devoted to the areas where the sisal industry is conducted.

The occurrence of the natural enemies of the sisal weevil should be studied on *Agave* spp. growing wild or unsuitable for the hemp industry, and on *Agave* growing in plantations (especially sisal, *A. sisalana,* and henequen, *A. fourcroydes*). The uncultivated *Agave* might yield a more extensive series of natural enemies, but one would be hampered in observations by the wild sporadic growth of the *Agave* and associated flora. Plantation practices make the weevil more readily available for observation and manipulation as well as more accessible to attack by natural enemies.

Because of difficulties experienced in making observations *in situ* on the uncultivated *Agave,* boles and the infested portions of flowering stalks should be stacked in wire screen cages and attempts made to associate any entomophagous fauna with the sisal weevil. Under plantation conditions, a more systematic programme could be adopted. Any natural enemies obtained from *Agave* plantations might be more adaptable to recolonization in plantations.

It should be emphasized, however, that the sisal weevil may have no parasitic or predaceous enemies and that, if these exist, they may be unable to maintain economic control of the weevil. There are certain injurious insects in the natural control of which entomophagous insects play no part or are of negligible importance. Before a further search for the natural enemies of the sisal weevil is undertaken it should be realized that the work involved would certainly be expensive and might be unproductive, though valuable information on other aspects of the problem might be obtained.

THE "CANKER" OR "BLACK LEG" DISEASE OF CABBAGES AND CAULIFLOWERS

By R. M. Nattrass, Department of Agriculture, Kenya

(*Received for publication on 6th March, 1951*)

The disease of cabbages and cauliflowers caused by the fungus *Phoma lingam* (Fr.) Desm., known as "Canker" in Britain and as "Black Leg" in the United States and elsewhere, has long been present in Europe. An early description of the fungus appeared in Germany in 1791 and it was described as a disease of cultivated *Brassicas* in France in 1849. It was established in Australia and New Zealand by 1897 and was first reported in the United States in 1911. In South Africa the disease is recorded as occurring in Natal in 1913 and in the Transvaal in 1920. It did not reach Kenya until 1944, when damage was caused to cabbages being grown for seed at an altitude of 7,700 feet. There is little doubt that the fungus was brought to Kenya in consignments of seed from abroad.

The earliest symptoms of the disease are seen in the seed bed in the form of spots or larger areas on the seed leaves and, later, slightly sunken elongated lesions on the stems. At this early stage fruit bodies, in the form of minute black dots, occur on the diseased tissue. When there is sufficient moisture, these produce masses of spores which are carried to later-formed leaves and healthy seedlings. Badly infected seedlings may wither and die.

A few slightly affected seedlings carried into the field at transplanting will, if conditions are favourable, spread the disease throughout the crop.

In the field crop, the plants may be attacked at all stages of growth. Leaf lesions may occur and the lower leaves become purplish in colour, but this symptom is not necessarily characteristic of the disease. The stems are most frequently attacked and may be girdled at or below soil level. There is usually a discoloration of the tissue on either side of the pith. Later, the root dies from below and turns black, giving rise to the term "Black Leg". On more mature plants, large cankers occur with splitting and disruption of the bark. The affected plants may continue to grow until the weight of the plant is too much for the weakened stem and root system: others may survive to produce seed when both seed branches and pods may become diseased. It is from the diseased pods that the seeds themselves become infected.

On land which has already borne an infected crop, the fungus remains viable on diseased leaves, stems and roots. Cruciferous crops should not, therefore, be grown again on such land for three or four years or even longer. The crop debris should, as far as possible, be collected and burnt.

In clean land, the disease is almost certainly brought in by diseased seedlings which have become infected in the seed bed. These seedlings are the result of sowing seed from a diseased crop. The seed can carry the fungus either by spores on the outside of the seed or by a dormant mycelium inside the seed coat. The destruction of the former can be accomplished by treating the seed with a suitable fungicide. This will eliminate a large proportion of the seed-borne infection but will not destroy the fungus within the seed coat. The only way of dealing with this is by the hot water treatment which is effective against both.

For many years the standard fungicidal treatment has been to dip the seed for 30 minutes in a 1 in 1,000 solution of corrosive sublimate. Owing to its very poisonous nature, it has, in recent years, given place to the less dangerous mercurial dusts, such as Agrosan, Ceresan, etc. All that is required is to shake the seed up in a closed tin or jar with about half a teaspoonful of dust to the one pound of seeds. A small packet can similarly be treated with a pinch of the dust.

The hot water treatment consists of immersing the seed, tied up in a muslin bag, for 25 minutes in water at a temperature of 122° F. A thermometer must be used and the temperature maintained by the frequent addition of water at a higher temperature. Little lattitude is allowed. If the temperature falls below, the fungus will not be killed; if it rises above, germination will be affected or the seed even killed. A sample of the seed which has been subjected to the hot water treatment should always be tested for germination before the bulk is sown. Neither treatment is, of course, necessary if seed is known to have come from a healthy crop. The mercurial dust treatment should not be omitted if the seed is from an unknown source or unaccompanied by a certificate of health. Seed testing laboratories can generally test samples of seed for the presence of *Phoma lingam*.

If, inspite of these precautions, diseased seedlings appear in the seed beds, they should be picked out and the remainder sprayed three or four times at intervals with a copper fungicide such as Bordeaux Mixture (4-4-50) to which a spreader has been added or with one of the proprietary copper fungicides. Dipping the seedlings before transplanting in the same fungicide would be worth a trial.

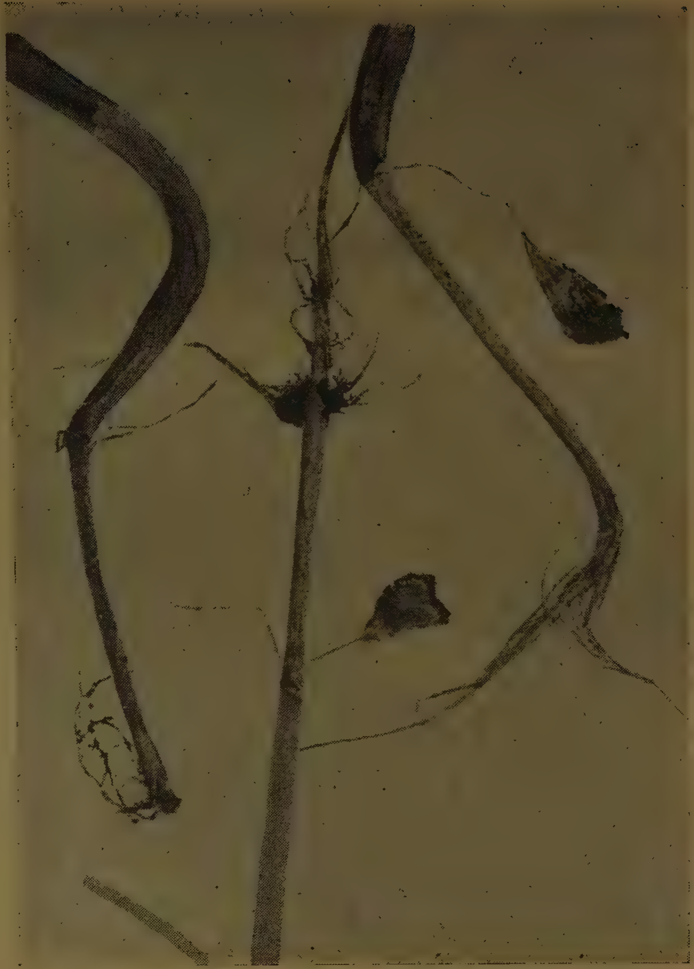

FIG. 1—Young cabbage plants raised from seed inoculated with spores of *Phoma lingam*, showing diseased cotyledons and blackening of the stems.

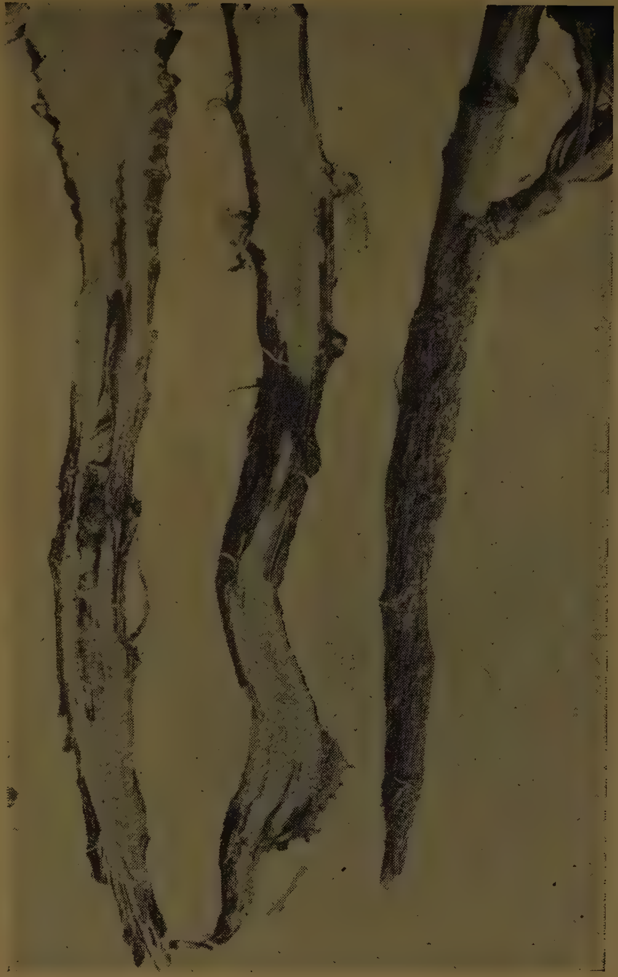

FIG. 2—Cabbage plants showing cankers at soil level and discoloration of the internal tissue.

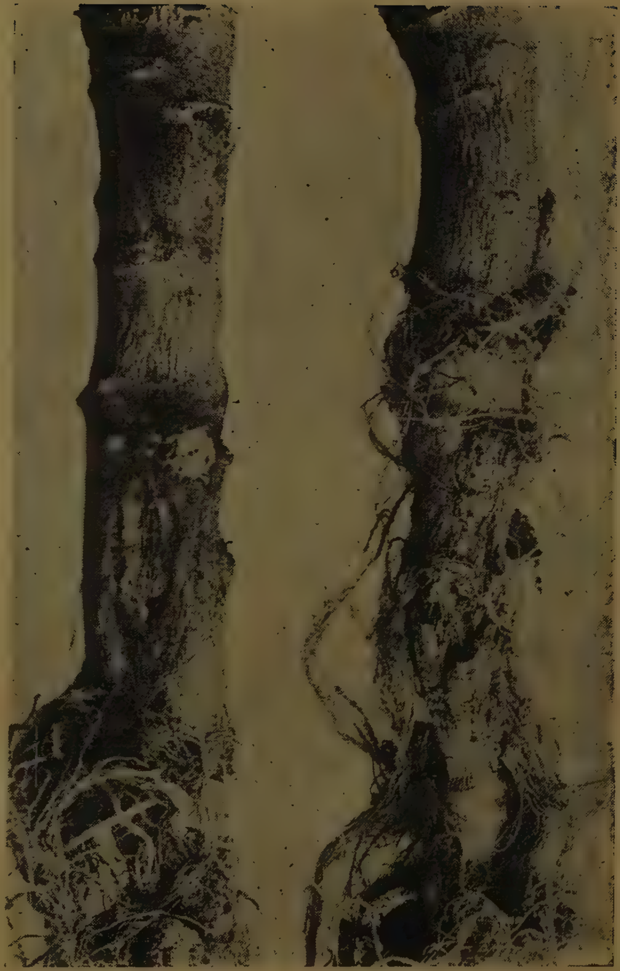

FIG. 3—Cabbage plants showing cankers and bark splitting below soil level.

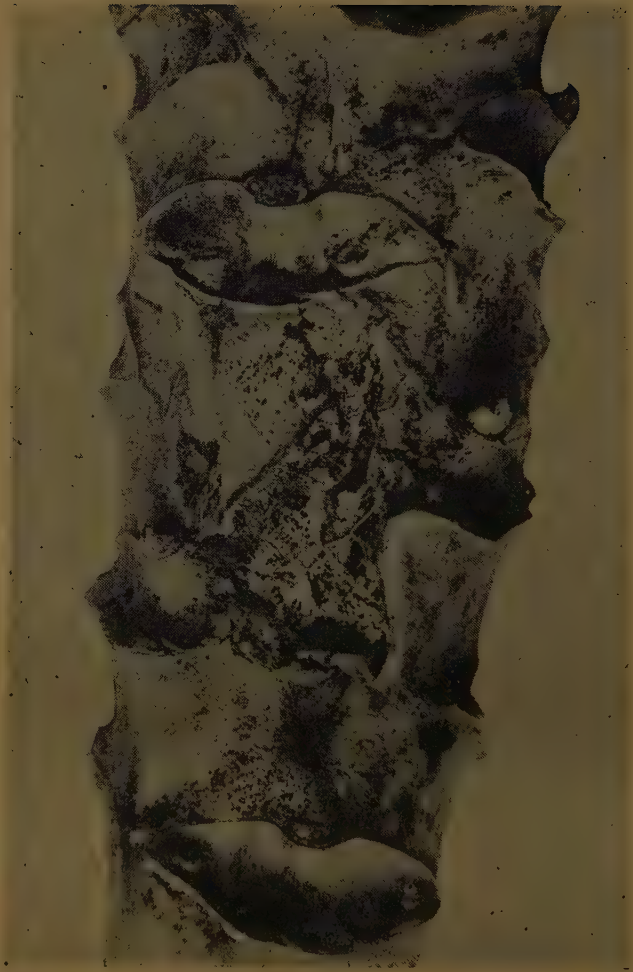

FIG. 4—Cabbage stalk showing fructifications of *Phoma lingum* × 2½

A BOTRYTIS DISEASE OF URENA LOBATA IN KENYA

By R. M. Nattrass, Department of Agriculture, Kenya

(*Received for publication on 29th January, 1951*)

Urena lobata is a perennial shrub of common occurrence throughout the tropics and is, in some countries, cultivated as a bast fibre crop.

Since 1948 a small plot has been maintained for experimental purposes at the Scott Agricultural Laboratories, Nairobi (5,700 feet). The plants flourished until July, 1950, when the whole plot was attacked by a severe stem canker disease. By this time the plants had attained a height of about four feet, each consisting of a number of basal vertical stems with laterals.

The cankers occurred at any point from ground level and attained a length of up to 15 centimetres, the larger ones girdling the stem and causing die-back or wither tip. The growing points were not directly affected. Few plants in the plot escaped having one or more cankers on either main stems or laterals. Basal cankers induced a flush of healthy shoots at ground level. No infected tissue was observed to extend below ground. The larger cankers had a bleached appearance, with occasional zoning and exudation of gum, and stood out clearly from the healthy tissue. On the surface of the cankers was a copious growth of coniophores and conidia of *Botrytis cinerea*, Pers. (Det. Commonwealth Mycological Institute.)

In every instance it appeared that the cankers originated at a node, each of which is furnished with a flower bud or cluster in the leaf axil, and that infection occurred through the flower bud. Stages in the formation of cankers could be traced from a dead flower bud to a small shield-shaped lesion at the base of the flower stalk. These early stages of the disease produced a pure growth of *B. cinerea* when kept in a moist atmosphere. No sclerotia were seen in the field either on the surface of the cankers or in the pith after some months of weathering. Sclerotia were formed in agar culture but not so readily as in other strains of *B. cinerea*. Pieces of cankered stems in a moist atmosphere in the laboratory continued to produce abundant conidia but no sclerotia. Sclerotia were, however, formed when similar pieces of stem were buried for three weeks in moist sand. These sclerotia, which burst through the bark, were more in the nature of sclerotial plates, being 1–2 mm. (occasionally up to 5 mm.) with a raised rim when dry and about 0.2 mm. thick, in marked contrast to the pulvinate sclerotia formed by the strain of *B. cinerea* causing a similar disease of *Eucalyptus* in Kenya [2]. No apothecia were developed from these sclerotia or from those produced in agar culture after being kept for several weeks in moist sand.

Infection of unopened flower buds readily occurred when conidia were blown on to severed twigs, previously atomized with water, and kept under a bell jar in the laboratory. Three days after inoculation the flower buds became discoloured. Eight days after inoculation the fungus had invaded the stem and leaf petiole. No direct infection was obtained on either stem or leaves.

The disease was a virulent one and sufficiently serious to render the cultivation of the crop unprofitable. After a lapse of some weeks of dry weather old weathered stems produced a crop of conidia during a wet spell.

B. cinerea is known to attack a wide range of host plants and to form cankers on woody perennials [1] [2] but it is believed to have not previously been recorded as causing a serious canker disease through flower infection.

REFERENCES

[1] Deacon, C. Edward (1932).—Some Effects of *Botrytis cinerea* on Roses. Trans. Brit. Mycol. Soc., 17, 331.

[2] Nattrass, R.M. (1949).—A *Botrytis* disease of Eucalyptus in Kenya. Emp. For. Rev., 28, 1, 60.

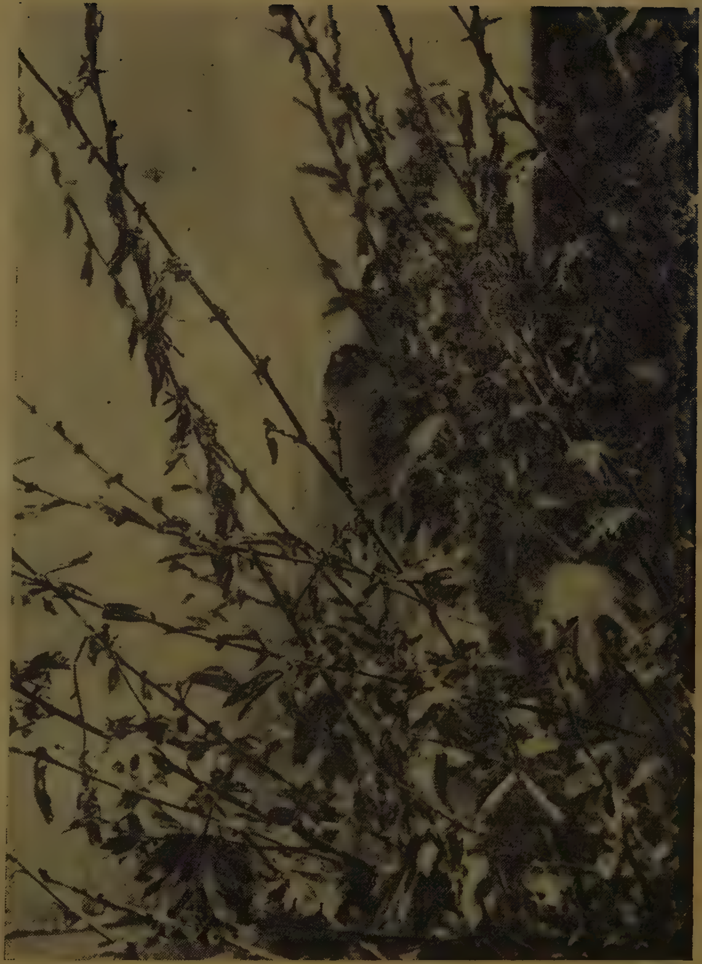

FIG. 1—*Botrytis* disease of *Urena lobata* L.

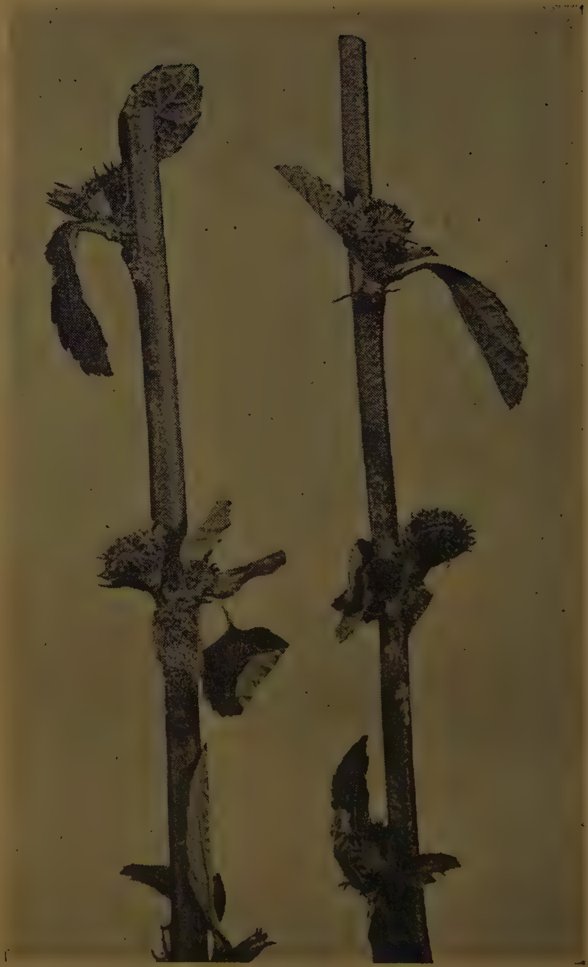

FIG. 2—Young cankers on main stem with healthy nodes above and below.

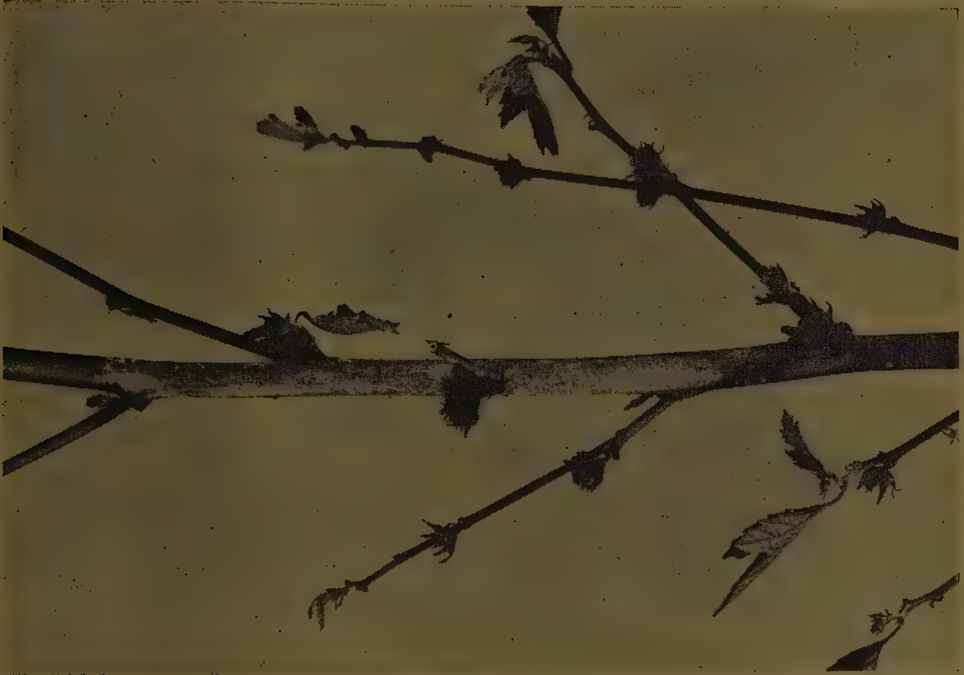

FIG. 4—Advanced canker showing bleached appearance of the bark and invasion of a lateral.

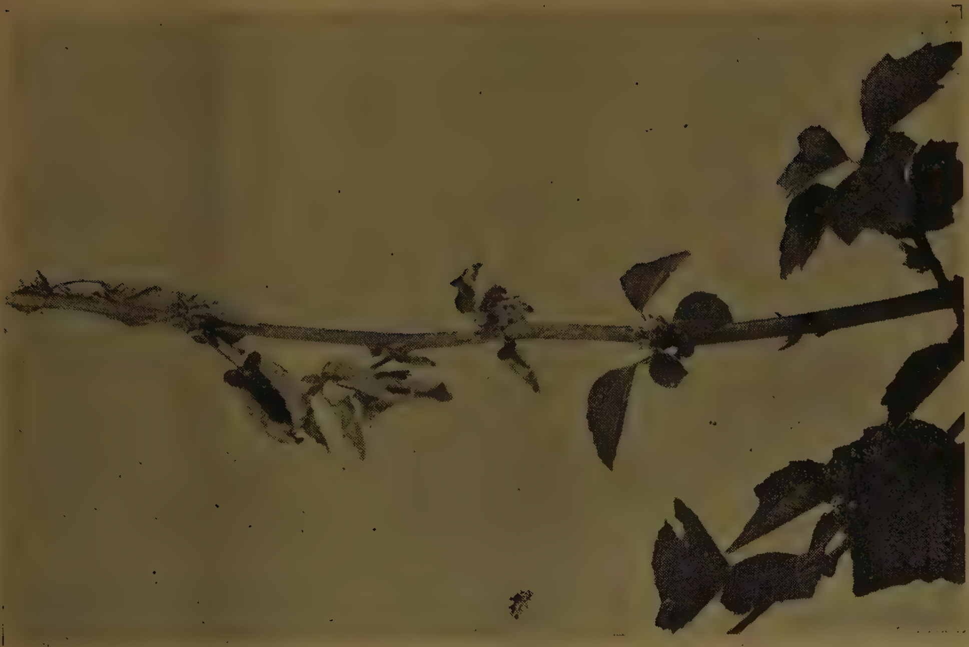

FIG. 3—Canker girdling the stem and causing "die-back".

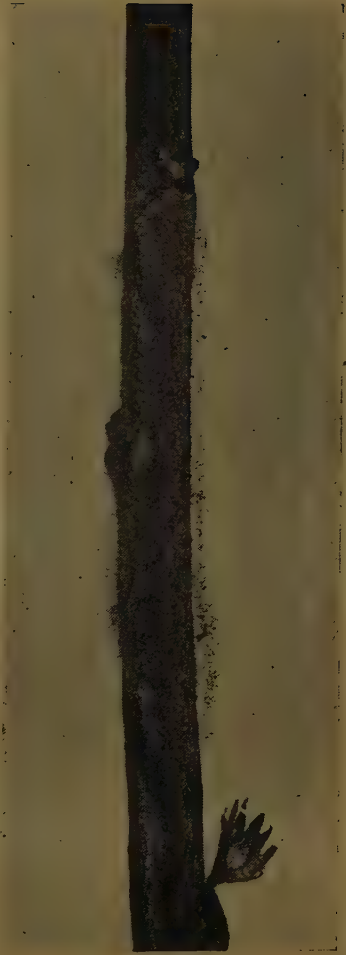

FIG. 5—Canker with conidiophores of *B. cinerea.*

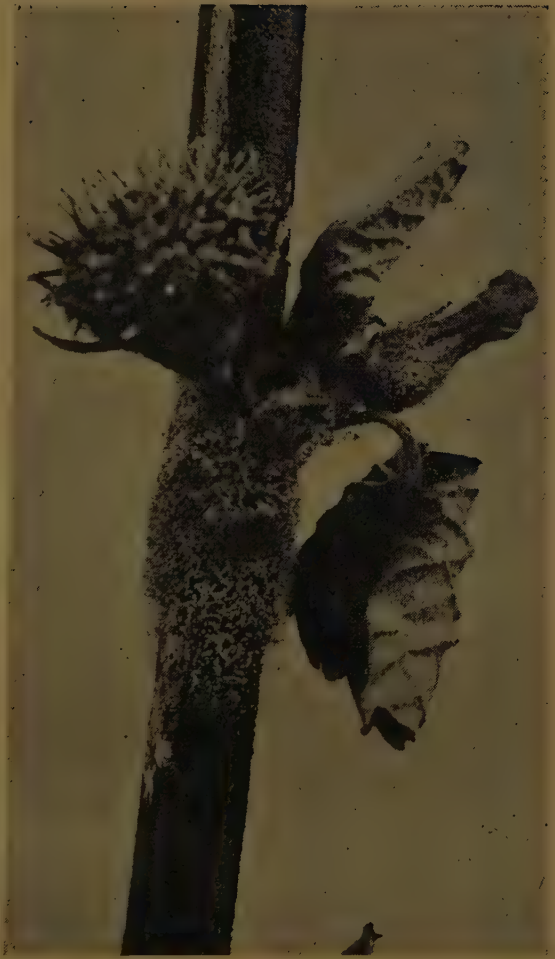

FIG. 6—Early stage of canker shown in Fig. 2. The flower bud, leaf petiole and stem are invaded by the fungus. The fruit is unaffected. × 2½.

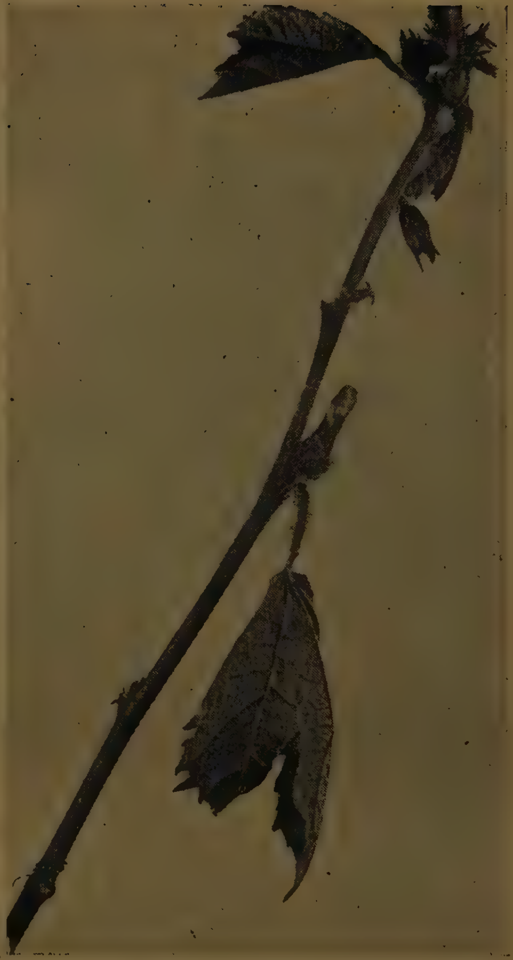

FIG. 7—Severed twig, eight days after inoculation with blown conidia.

PRELIMINARY REPORT ON TRIGONA WAX

By F. G. Smith, Beeswax Officer, Department of Agriculture, Tanganyika

(*Received for publication on 10th February*, 1951)

While visiting beeswax refiners and London merchants in August and September, 1949, my attention was drawn to a dark, sticky wax which had been arriving in consignments of beeswax from Tanganyika. The trade called this wax wasp wax, though its true origin was unknown. The pieces of this sticky wax were usually to be found in a number of bags in a consignment, and well mixed in the bag with pieces of pure beeswax. Frequently, the top layers in a bag would be good beeswax, while much of the rest of the bag would be wasp wax.

Refiners found that should wasp wax and beeswax be melted up together, the whole took on the stickiness of the wasp wax. Cosmetic manufacturers reported that although it was possible to make an emulsion with the sticky wax in the laboratory, it was not an economic manufacturing proposition, and so the wasp wax was useless to them, as was any beeswax that had been melted with the wasp wax. The consultant analysts in London, although familiar with the sticky wax, had been unable to determine its origin. It appeared therefore that the substance was a wax closely related to beeswax. From the description by Warth [1] of beeswax adulterated with the wax of stingless bees (*Meliponidæ*), experience of which had been suffered in America, it appeared that there was a possibility that this sticky wax was stingless bees' wax.

On arrival in Tanganyika, it was learned that the sticky wax came mostly from the Central Province. Inquiries at Tabora brought forth the information that it sometimes came from Nzega and Kiwere, situated in the north-east and south-east of the Western Province respectively, both of which areas border on the Central Province. A sample of slightly sticky wax was obtained in Nzega, but analysis by the Government Chemist showed it to be apparently beeswax. Later, however, at Kiloli in Kiwere, the information was volunteered that a sticky wax was obtained from a small, dark bee called Upula. This sounded promising, and the local trader undertook to send me a sample as soon as he could.

Following the complaints about the quality of Central Province beeswax, a visit was paid to that area. At Itigi, Upula or Pula wax was known, but no samples were available. At Manyoni, not only was Pula wax known, but one trader had 200 kilos of it which Dar es Salaam beeswax shippers refused to accept. A promising-looking cake was bought. Later, cutting the cake in two, to send half to the Government Chemist for analysis, the bodies of small insects became visible. The half that was retained was melted in an enamel bowl floating in hot water, and the wax strained. After cleaning the residue, microscopic examination showed the bodies to be those of stingless bees (*Meliponidæ*) of the genus *Trigona.*

Subsequently, samples of *Trigona* wax were obtained from Dodoma, Singida, Urugu, Mpwapwa, Kwa Mtora, Bareku and Handeni. The trader at Kiloli sent in a sample, which had not been melted, and from its appearance it was composed of crushed combs. Straining and microscopic examination revealed the presence of *Trigona* in every cake, except one from Mpwapwa.

The Stingless Bees

The *Meliponidæ*, a family of the *Apoidæ*, closely related to the *Apidæ*, is divided into three genera, *Melipona, Lestrimelitta* and *Trigona.* In this paper we are concerned with *Trigona.* The principle characters of *Trigona* are as follows:—

(1) Joint 3 of antennæ is shorter than joints 4 and 5.

(2) Outer face of hind tibiæ either more flattened at the apex than towards the base or depressed or excavated at the apex; some species with the excavation extending almost to the base.

(3) A tibial comb anteriorly at the apex of the hind tibiæ.

(4) Stigma rounded below, wings relatively long.

(5) Hamuli per lower wing range between 4 and 8, rarely 10.

(6) Body length between 2 and 8 mm., very exceptionally 11 mm.

Trigona species are frequently met with in Tanganyika particularly the diminutive Trigona of the sub genus *Hypotrigona,* which has the annoying habit of hovering round the face and settling on arms and legs and is commonly called the sweat bee.

Nests.

The nests of *Trigona* are to be found in any convenient hollow. *Trigona Hypotrigona* is frequently seen nesting in walls, pillars, as well as in trees. The larger *Trigona* nests are usually found either in holes in the ground or in hollow trees, and sometimes externally on trees. It is reported that the hollows left in the ground where some corpse has rotted away are sometimes used. In Kiwere, those that nest in trees are called Upula, and those in ant hills, Mgaga. Another species called Ipilia nests in the ground or in trees and is said to sting. The tiny *Trigona Hypotrigona* is known as Mpunzi. In the Central Province, where most of the samples were obtained, the wax is said to be obtained from nests in the ground, Pula being the usual name for the insect.

The entrance to the nest is frequently in the form of a tube or trumpet extending outwards. In the nest the brood combs are usually arranged horizontally, and consist of a single layer of cells with their mouths upwards. These combs are supported in tiers by pillars of wax. In some species, and in particular *Hypotrigona*, the cells are clustered and separated by minute pillars of wax. In the case of the comb-building species, the brood nest is enclosed in an involucrum which may be of wax or may contain other substances. The honey and pollen is stored in waxen jars which are arranged in clusters.

Among the things *Trigona* species collect and carry off to their nests, Schwarz [2] lists water and perspiration, secretions of insects, animal juices, sugar, fruits, and resins, tar, grease, oil and varnish, excrement and urine, moist bread, Christmas cake and old stinking cheese. Of these, the most important are resins. *Trigona* will attack the trunks and branches of trees, which they scar and strip off the bark, as well as nipping off shoots, in order to obtain the gummy secretions. Stores of such material are reported as being found in nests. Resinous substances are used widely in the construction of the nest.

Identification of Trigona Wax

Stickiness.

The first characteristic that is observed on handling a piece of *Trigona* wax is its stickiness. If the edge of the cake is held between the fingers and thumb it can be drawn out like well-chewed chewing gum. When the *Trigona* wax is mixed with beeswax, the stickiness is readily detectable down to 25 per cent adulteration. At 10 per cent adulteration, the stickiness of the *Trigona* wax is noticeable when compared with a cake of pure beeswax, but at 5 per cent adulteration it is hardly detectable at all.

Smell.

Trigona wax has a characteristic smell, and in the opinion of some, a characteristic taste too. The finer variations of the reactions of the senses of smell and taste are very difficult to describe. Whereas beeswax has a floral odour, *Trigona* wax has a pungent smell rather reminiscent of varnish. To smell the wax it is best to cut it and smell the newly cut surfaces. In cases of uncertainty, heating the wax until it melts enables the volatile substances to be smelt easily. If, however, there is more than 90 per cent beeswax present in the sample, the pungent odour of the *Trigona* wax may be swamped by the aroma of the beeswax.

Presence of Trigona *Remains.*

Providing the wax has not been strained through cloth, there are almost certain to be the remains of the bodies of adult *Trigona* present. This is due to the nature of the *Trigona* nest which makes it very difficult to collect the wax without getting some of the small bees too.

In some cases the whole bodies of *Trigona* may be present, but usually only broken off legs, wings, heads and body segments are found.

To separate the body parts from the wax, the cake should be melted in a bowl floating in a larger vessel of water. The liquid wax is poured through fine wire cloth into another bowl. A considerable amount of rubbish and wax will be left on the wire cloth. This is washed by pouring boiling water over it. When as much wax as possible has been washed through, the wire cloth is turned upside down over a bowl and the remains washed off the cloth into the bowl with boiling water. The remainder of the wax is dissolved by putting the remains in turpentine and heating. When all the wax is dissolved the remains of the bodies can be picked up from the rubbish for examination.

Identification of Species.

The wing venations in the two species so far encountered are identical. The wings provide characteristics for the identification of the genus, with the stigma rounded below, and the presence of six hamuli, occasionally five, in the species encountered. The hind tibia is a valuable source of characters for the identification of the species. The hind tibia is excavated at the apex on the outer face in each case, and the apical tibial comb is present. *Trigona* species "A", identified by

Mr. G. E. J. Nixon of the Commonwealth Institute of Entomology as *T. denoiti*, Vachel, has a sub-triangular-shaped hind tibia, while *Trigona* species "B", possibly *T. partamona*, is pear shaped, very broad and has a spoon-shaped excavation on the outer face.

The mandibles are another useful guide to identification. Fortunately the heads seem to survive pretty well intact and the mandibles are readily removed with a needle. In the case of the two species found in *Trigona* wax, Species "A" has two small teeth on the mandible, separated by a shallow rounded cleft. Species "B", on the other hand, has two prominent teeth separated by a deep cleft. The extremity of the mandible is less pointed than species "A", both the outer and inner edges being curved, whereas in species "A" the outer edge is almost straight.

Chemical Analysis of Trigona Wax

Nineteen samples of *Trigona* wax or suspected *Trigona* wax have been submitted to the Government Chemist for analysis. Fourteen of the samples contained the remains of *Trigona* species, of which six were species "A", five were species "B", one contained both species "A" and "B" and in the remaining two cases, *Trigona* remains were present but not identified. Of the 14 samples containing *Trigona* remains, three appeared to have some beeswax present also. There may have been beeswax present in other samples, but it was not obvious.

The eleven samples believed to be reasonably pure *Trigona* wax had the following characteristics:—

	Trigona Wax	*Normal for Beeswax*
Saponification value	41.5 –84.2	85 –100
Acid value	7.7 –20.8	17 – 21
Ester value	32.1 –70.2	74.5 – 87.1
Iodine value	37.1 –60.9	6.8 – 16.4
Specific gravity ..	0.963– 0.975	0.955– 0.970
Setting point	58.0 –61.5	61 – 62.5

Every one of the 19 samples gave positive results to both Weinwurm and Sterol Group Tests. Beeswax is negative to both tests. The characteristic figures for beeswax for the saponification and acid values, specific gravity and setting point are those laid down in the Government Chemist's specifications [3]. For the ester value of beeswax, Salamon [4] gives 74.5, Warth [1] gives 87.1 for Kenya beeswax, and Buchner [5] gives 79.4 for African beeswax. Buchner's iodine value for African beeswax is 11.6, and that of Vansell and Bisson [6] between 6.8 and 16.4.

Adulteration of Beeswax with Trigona Wax

To determine what degree of adulteration could be detected, beeswax and *Trigona* wax were mixed in carefully weighed proportions.

The beeswax used was a composite sample from many sources and had the following characteristics:—

Saponification value ..	98.2
Acid value	18.0
Ester value	80.2
Iodine value	9.2

The sample of *Trigona* wax, believed to be pure, had the following values:—

Saponification value ..	44.9
Acid value	10.7
Ester value	34.2
Iodine value	56.1

and was positive to Weinwurm and Sterol Group Tests. 25 per cent, 50 per cent and 75 per cent adulteration produced values outside the range for beeswax and the stickiness and odour of *Trigona* wax was obvious. 10 per cent adulteration showed in the low saponification and ester values, high iodine value and positive reaction to Sterol Group Test. The sample had a faint trace of stickiness but the smell of beeswax. 5 per cent adulteration gave values within the beeswax range but the Sterol Group Test was positive. In appearance the cake did not differ from ordinary beeswax.

The Future of Trigona Wax

In an effort to obtain a market for *Trigona* wax, samples have been supplied to merchants, manufacturers, and industrial chemists in both the United Kingdom and the United States. Particulars of chemical and physical characteristics have also been supplied. As yet no use has been found for *Trigona* wax in the United Kingdom but it has been intimated that the United States might be interested in buying it, where, in the past, it has been used in the boot and shoe trade. Owing to the limitations of its use, the value of *Trigona* wax would be very much lower than that of beeswax.

REFERENCES

[1] Warth, A. M.—"The Chemistry and Technology of Waxes", Reinhold Pub. Corp., New York (1947).
[2] Schwarz, H. F.—"Stingless Bees (*Meliponidæ*) of the Western Hemisphere", Bul. Amer. Mus. Nat. Hist. (1948).
[3] Government of Tanganyika Territory. Government Notice 196 published 20-7-45. Supplement No. 2 to the Tanganyika Territory Gazette, Vol. XXVI, No. 35 (1945).
[4] Salamon, J. S.—"Chem. Ind.", 35, 8–10 (1916).
[5] Buchner, G. V.—"Chem. Ztg.", 42, 373–374, 1918).
[6] Vansell, G. H., and Bisson, C. S., U.S. Dept. Agric. Bur. Ent., Plant Quarantine, E–495 (Feb., 1940).

"FIVE-MINUTE BALANCED RATIONS"

By B. O'Donohue, Delamere Estates, Elmenteita, Kenya

(Received for publication on 27th February, 1951)

Many farmers would be more inclined to calculate balanced rations for their stock if they knew of a quicker method than those generally shown in the text books.

"Balancing a ration" generally means achieving in a mixture of foods a correct ratio between the carbohydrate and protein portions of those foods. This ratio varies according to the purpose for which the food is required. For example a milk production concentrate food should have a carbohydrate/protein ratio of 5:1; whilst a pig fattening ration on the Lehman system needs a concentrate ratio of 3.25:1

The following method should enable the calculation to be done in about five minutes.

The first thing to be done before a ration can ever be worked out is to obtain a list of feeding-stuffs and their analysis. These are to be found at the back of almost all text books on animal husbandry or else a list can easily be obtained from the Ministry of Agriculture. The amount of carbohydrate in a food is usually stated in terms of the amount of "Starch Equivalent" and the amount of protein in the food as "Protein Equivalent" (afterwards referred to as S.E. and P.E. respectively).

It is not within the scope of this article to explain these terms; what matters most are the figures in the columns headed Starch Equivalent and Protein Equivalent. For example it will be noticed that for oats the S.E. is given as 60 and the P.E. as 6.5 and for cotton seed cake the S.E. is 68 and the P.E. 34. Now it will be seen that the ratio between 60 and 6.5 in the case of oats is about 9:1 and in the case of cotton seed cake the ratio between 68 and 34 is 2:1. Thus neither of these foods by themselves are suitable for a milk producing ration which, as we have stated, needs a ratio of 5:1. In order to know in what proportion to mix these foods so as to acquire the correct ratio of 5:1, the foods and their analysis should be set down in the following manner:—

	S.E.	P.E.
1 part oats	60	6.5
1 part cotton seed cake ..	68	34.0
	128	40.5

Now it will be seen that the ratio between 128 and 40.5 is about 3:1 and that this is still not the correct ratio. There is either too much P.E. or, conversely, too little S.E.

To the above figures we can continue to add 1 part of oats until the correct ratio is obtained:—

	S.E.	P.E.
1 part oats	60	6.5
1 part cotton seed cake ..	68	34.0
	128	40.5
Add 1 part oats	60	6.5
	188	47.0
Add 1 part oats	60	6.5
	248	53.5
Add 1 part oats	60	6.5
	308	60.0

A rapid way of determining whether the P.E. is one-fifth of the S.E. is to multiply it by five after every addition of oats. It will be seen that if the P.E. which has added up to 60, is multiplied by five it will be 60 × 5 = 300 which is as near to 308 as makes no difference.

Thus by mixing 4 parts of oats with 1 part of cotton seed cake the result is a ration with a 5:1 ratio between S.E. and P.E. It makes no difference if the "parts" be ounces, pounds, hundredweights or tons so long as the parts are kept the same for each of the foods. If one wishes to make a small amount of the mixture for one cow for one feed, then 4 lb. of oats can be mixed with 1 lb. of cotton seed cake or 8 lb. of oats with 2 lb. of cotton seed cake. To make a ration for a week for a herd the mixing would be 16 cwt. of oats with 4 cwt. of cotton seed cake.

The above example is a simple one using only two different foods whereas a really good ration for high class dairy cows should include as many foods as possible, say about six. The following is the construction of a ration using six different foods:—

	S.E.	P.E.
3 parts oats	180	19.5
1 part copra cake	76	16.0
1 part bran	50	11.0
1 part oat bran	45	3.8
1 part maize meal	80	8.0
1 part protein meal (or fish meal or meat and bone meal)	80	44.0
	511	102.3
		5
		511.5

The next thing to be done is to find the quantity of this mix that should be fed per gallon of milk. This will depend on two factors (*a*) the average butterfat content of the milk being produced; and (*b*) the average S.E. figure of the mixture just calculated.

The average S.E. of the mixture is found simply by dividing the total S.E. figure at the end (i.e. 511) by the number of parts of the ration—in this case 8. So that 511 divided by 8=63.8—or 64 for convenience.

To find the amount to feed per gallon of milk of various butterfats divide the average S.E. of the ration into the following figures:—

For 3.5% B.F. milk divide average S.E. into 250.
For 4.0% B.F. milk divide average S.E. into 260.
For 5.0% B.F. milk divide average S.E. into 325.
For 6.0% B.F. milk divide average S.E. into 360.

For example: if the average S.E. of the ration be 64 and the milk to be produced is from Jerseys at 5 per cent butterfat, then 325 divided by 64 equals 5. Thus feed 5 lb. of the mixture per gallon of milk. If only 3.5 per cent butterfat milk is being produced then feed 250 divided by 64 equals 4 lb. per gallon.

REVIEW

Commercial Methods of Testing Milk and Milk Products, by J. Lyons and M. J. O'Shea (pp. viii + 218) (Cork University Press, 1950. Sh. 15).

The authors preface the book with the statement that it "is intended to provide students and persons engaged on the technical side of dairying with information about the tests usually carried out where milk is treated for the liquid milk trade, or is manufactured into dairy products". The first three chapters give a brief account of the nature of milk and the causes of variations in its composition, whilst the remaining fifteen chapters give detailed information on methods for obtaining representative samples, the estimation of fat in whole milk, cream, separated milk, buttermilk and whey, the determination of solids-not-fat, the general methods for analysing butter, cheese and concentrated milk products as well as details for examining the sanitary quality of milk and the efficiency of pasteurization processes.

The book collects together all the more commonly used methods of analysis and gives hints on the precautions which have to be observed to avoid faulty results. The material is presented in an easily readable manner and the explanations and directions are given in simple language. Many examples are given to show the arithmetic procedure for expressing the test results in the usual terms of the dairy industry.

For students, persons taking up employment in creameries for the first time, and for farmers who wish to carry out regular tests on the quality of their milks, the book will provide the basic information they require with a minimum of unnecessary knowledge and detail.

M.H.F.

WATERSHED MANAGEMENT RESEARCH IN THE U.S.A.*

By A. L. Griffith, E.A. Agriculture and Forestry Research Organization

(Notes on a tour in the U.S.A. in September to November, 1950. The tour was E.C.A. Project O.E.E.C. 18/B, Group 4, Tropical Forestry. Grateful acknowledgement is made to the U.S.A. for providing the dollars to make this interesting and instructive tour possible, and to the U.S. Forest Service and Soil Conservation Service, for their hospitality, arrangements, and helpful information so freely given.)

General History

Catchment Area Research or to use the American term Watershed Hydrology started with the famous Emmenthal experiment in Switzerland in 1906, which compared two catchment areas one of which was forested, and the other partly forested.

This was followed in the U.S.A. by the Wagon Wheel Gap experiment (Colorado) in 1915. This compared two watersheds, both of which were forested, but one of which was artificially denuded after establishing climatic comparability between the two. Other experiments followed in Utah, California, and S. Carolina.

The hydraulic engineers would not accept the Emmenthal or Wagon Wheel Gap results as conclusive for a number of reasons. It was also felt that the Utah, California and S. Carolina experiments were on small plots or small watersheds, or were studying particular aspects of the problem.

The hydraulic engineers demanded seven conditions for the selection of watersheds: these are listed later under Coweeta. In consequence, the U.S. Forest Service with the engineers searched the U.S.A. for over two years, and examined over 200 watersheds before they found Coweeta in the Nantahala National Forest of N. Carolina, which fulfilled all the engineers conditions. This is an area of 5,700 acres, and contains 40 independent watersheds all of which are in one main catchment area, and contribute to the one final outlet river. Work started in 1934, and after calibrating the climate, etc., of the whole area the first treatments were applied in 1940.

The following notes describe visits to the work in Utah, California, S. Carolina, and Coweeta (N. Carolina).

Utah, Parrish Creek

The work was undertaken not only from the point of view of scientific research, but mainly because of the divergence of the opinions held by the local public as to the merits of different kinds of vegetation, and of no vegetation, on stream flow, erosion, grazing and floods. This public consisted of farmers, fruit growers, stock raisers, and office workers owning houses in the countryside.

Description of the Region.

The study was conducted on a number of plots situated near the head of Parrish Creek near Ogden, Utah, at an elevation of about 9,000 ft. The rainfall is about 30 in. per year and this comes in winter snow (equivalent to about 22 in. of rain) and summer storms totalling about 8 in. These storms are sudden and of high intensity, lasting 5 to 15 minutes with an intensity of 2 to 3 in. per hour. It is these storms that cause the erosion damage, and not the winter snow.

In the summer the surface soil dries out, and when the storms come, has to be wetted to field capacity before any water is available for stream flow. This drying out causes a "dry mantle". When the snow melts it has to raise the soil moisture content to field capacity, and then the water percolates and becomes available for stream flow. Later in the season the soil dries out by evaporation and by transpiration of the vegetation. This vegetation, however, stops (or minimizes) surface erosion, and hence run-off and floods.

The natural vegetation of the area was originally Alpine Fir (*Abies lasciocarpa*), Aspen (*Populus tremuloides*), Black Balsam or White Fir (*Abies concolor*), Colorado Blue Spruce (*Picea pungens*), Engleman Spruce (*Picea engelmanii*) and Limber Pine (*Pinus flexilis*), together with shrubby growth of Oak brush (*Quercus gambelli*) and Maple (*Acer grandidentata*).

This was interspersed with areas of gress and herbs.

Under the influence of fire and very heavy grazing of the early settlers, this vegetation was reduced to very poor grass and herbs, with scattered conifers. In many places the vegetation was of quite thick aspen with or without grass and herbs.

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* Text of a paper read to the Nairobi Scientific and Philosophical Society on 13th March, 1951.

Purpose of the Investigation.

The purpose of the investigation was: to discover how much water is taken from the soil each season by the processes of evaporation and transpiration of (1) aspen-herbaceous vegetation; (2) herbaceous vegetation; and (3) bare soil: to find out whether or not some of the water used by the vegetation might be conserved for stream flow by removing part of the vegetational cover: to find out whether a reduction in the amount of vegetal cover can be done without exposing the soil to damage by excessive surface run-off and erosion.

The work done was carried out on three types of plots:—

(*a*) Plots covered with natural aspen and herbaceous vegetation.

(*b*) Plots as (*a*) but from which the aspen was removed to leave only herbaceous vegetation.

(*c*) Plots as (*a*) but from which *all* vegetation was removed to leave bare ground.

Measurements were taken of: surface run-off; soil eroded; precipitation at ground level; total water lost by evaporation and transpiration; pre-field capacity use of water by the vegetation (because the trees, etc., come into leaf and grow before there is any precipitation).

These are best explained by the calculation formulæ:—

(A) $$W = \frac{M\%}{100} \times G \times D$$

where W = water in the soil in inches depth.

M = moisture content in per cent.

G = apparent density of soil (Sp. Gr. of soil and water content combined).

D = depth of soil in inches.

(B) $$L = (W_1 - W_2) + (P - R) + F$$

where L = total water lost by evaporation and transpiration.

W_1 = moisture content in inches depth at field capacity.

W_2 = moisture content in inches depth at depletion stage. (End of period.)

P = precipitation at ground level over the period (i.e. the effective precipitation).

R = run-off over the period.

F = pre-field capacity use.

Note. L also includes condensation, some of which runs down the trees, evaporation from the soil, and other similar incidentals which have not yet been separately determined.

$W_1 - W_2$ is known as the evapo-transpiration deficit.

W_2 is the depletion point.

The field capacity (W_1) was empirically taken to be the moisture content of the soil immediately after snow or heavy early summer rains.

The depletion point (W_2) was determined by taking the moisture content of the soil at the end of the growing season.

Results.

The mean total evapo-transpiration water losses per year (L) over the three-year period 1947-1949 for each cover type were:—

Bare ground	10 in.
Herbaceous	14 in.
Aspen-herbaceous ..	17 in.

However, summer precipitation has little if any effect on stream flow unless run-off occurs, as the rain is absorbed by the soil and soon lost to the atmosphere. All the water that reaches the stream passes through the soil while the mantle is wet (i.e. at field capacity) and comes largely from the winter snow and early spring rains. Therefore, the dryness of the soil (evapo-transpiration deficit) determines the amount of water from any given snow deposit that will pass through the soil and thus become available for stream flow.

The average annual evapo-transpiration deficits for the three types over the three-year period were:—

Bare ground	4 in.
Herbaceous	8 in.
Aspen-herbaceous ..	12 in.

from this it follows that bare ground uses 4 in. per season, herbaceous cover uses 8 in. or 4 in. more than bare ground, aspen-herbaceous cover uses 12 in. or 4 in. more than herbaceous cover or 8 in. more than bare ground.

It is estimated that the aspen-herbaceous type uses 1 in. of free water in excess of its evapo-transpiration deficit (as measured) because flowering and leafing occurs while snow is on the ground, and free water is passing through the soil. That used by herbaceous cover alone was not estimated.

The study of erosion and run off showed that during the period the herbaceous cover alone provided almost as much protection for the soil as did the aspen-herbaceous cover.

Conclusion.

This study therefore indicates *that in this region under these conditions* and in *this period* the removal of the aspen would have added about 4 in. more water per year for stream flow, and that such a removal would not have resulted in excessive run off or soil erosion as long as the required minimum of herbaceous cover was maintained.

Comment and Discussion.

A great deal of work and a great deal of argument on this subject is going on in many parts of the world. It is therefore necessary to comment that the above figures are of very local application for the following reasons:—

(*a*) The only tree species experimented with was aspen which is notoriously a "thirsty" species.

(*b*) Root studies showed that the roots in general penetrated as follows:—

Grass and herbaceous species—down to 3 ft.

Aspen—down to 6 ft.

This is different from East African conditions, where root studies have shown the following depths:—

Bamboos—down to 3 ft. and sometimes to 6 ft.

Conifers (pines and cypresses)—down to 6 ft. to 10 ft.

Grass—sometimes as deep as 25 ft.

Therefore, to apply these data to determine policy in East Africa, would be very dangerous indeed.

(*c*) Factors such as condensation of dew and mist by trees, have not been measured, and *may* be considerable.

(*d*) The difference in effect of aspen-herbaceous and of herbaceous cover as compared with bare ground (12 in. – 4 in. = 8 in. for aspen-herbaceous and 8 in. – 4 in. = 4 in. per herbaceous) are relatively small when compared with the total precipitation of 30 in. Of course, this may be locally very important.

(*e*) These results come from small plots only.

General Indications.

This work thus appears to indicate that some sort of vegetative cover is vitally necessary to minimize run-off and erosion and make water available for perennial stream flow: that at this stage it is not possible to say whether the cover should be trees, herbs, or grasses, or a combination of all three types: that the problem (and its answers) are probably essentially local.

CALIFORNIA, SAN DIMAS EXPERIMENT STATION

Similar work on the water consumption of vegetation was seen at the San Dimas Experiment Station on 16th October. The set up was much more elaborate, and the equipment more modern, but no results are yet available. It is to be written up as an interim report—probably in the next six months, and this report, of twelve years work, is awaited with great interest.

Description of Area and Work Done.

The lysimeters are constructed on flat land at an elevation of about 2,500 ft. and a rainfall of about 25 in. The range of rainfall annually is, however, fairly wide.

Twenty-six concrete tanks were constructed each 10 ft. × 20 ft. × 6 ft. and were filled with the original soil in its original depth layers. An additional 1 in. of soil was put on top and allowed to settle for three years. Then in all plots, grass (*Bromus mollis*) was planted and allowed to grow for four years to create a soil structure. The plots were then planted with local species, five replications of five species, and one control plot kept bare. Each plot had a surround, and it is noticeable that growth on the surround is very much better than in the plots even after five years, showing that the experimental area is still very artificial.

The species used are:—

Scrub oak (*Q. dumosa*).
Pinus coulteri.
Ceanothus oliganthus.
Adenostoma fasciculatum (Chamise).
Eriogonum fasciculatum (Buck wheat sage).
Control—Bare.

Measurements.

Measurements have been taken so far for five years, of precipitation, run-off, percolation, evaporation and hence the evapo-transpiration deficit for each type calculated by the usual formula. The evaporation from the soil is a rather doubtful factor obtained from the bare soil and open pans, and then adjusted to the percentage of vegetation in the plots. Other factors such as interception, condensation, etc., are included in general (as in the case of Utah) but not yet measured in detail.

Percolation or seepage is measured by both soil sampling and also electrically. Root studies of the different species are being made under both natural conditions and those of the experiment.

Results.

The experiment has been running now for 12 years, three years construction, four years grass, and five years actual species measurement. Interim results are to be put out shortly, but it is expected that they will be of only local application and proportional between species rather than absolute at this stage. They should, however, provide a very important comparison with the Utah figures already described.

Critique.

In Utah the only tree species used is aspen, which is notoriously "thirsty". The California comparisons of the usage of the pine, scrub oak, chamise, etc., with the aspen and grass and herbs of Utah should be very illuminating, and should enable a very rough estimation to be made of the water usages of other types of vegetation in other parts of the world provided the same general basic data have been collected for a sufficient period of time.

SOUTH CAROLINA—CALHOUN EXPERIMENTAL FOREST

Work in this area is small scale intensive experimentation endeavouring to find out the magnitude of certain specific effects, and to try and tie them into general results of the small watersheds, 15 acres each, in which they are being measured.

Description of the Area.

Elevation 800 ft. and rainfall 50 in. Two small watersheds of about 15 acres each. The area was old abandoned cotton fields. One watershed now contains a good plantation of *P. taeda* while the other is bare.

Work Done and Measurements Taken.

Temperature measurements taken in the neighbourhood, show that in general the air under hardwoods is 7° to 12° F. cooler than under the pines. Also, the maximum soil surface temperature is about the same.

Thus from the point of view of temperature, the same precipitation is less effective under the pine than under hardwoods.

Interception.—Rain gauges inside and outside the plantation show that 40 per cent (i.e. about 20 in.) of the precipitation is intercepted, and measurement of the precipitation running down the stems of the trees show that one-half of this interception reaches the ground in this way (i.e. about 10 in.). The residue of this interception is either evaporated or absorbed by the trees.

Retention of Water by the Litter.—Trays exposed in various ways show the amount of water exaporated by the soil and the amount that is retained by the litter.

This water retention of the litter as a maximum is $\frac{1}{10}$ in. held from a storm of 3 in., but in five days this had decreased to 1/100 in. Hence we cannot rely on litter alone to stop complete run off, and the surface soil *must* be made to hold the water.

Electrical measurements then follow the storm water down through the soil to a depth of 6 ft. after each storm. The site is poorly permeable at the rate of about 5/100 in. per hour.

Temperatures and relative humidity are also measured both inside and outside the plantation.

Results.

These experiments were only started early this year (1950) and hence detailed results have not yet been obtained.

In general, however, it is indicated that the pine (*P. taeda*) takes water down to a depth of 6 ft., while the broom sage (*Andropogon scoparius*) crop takes water down to about 30 in. These results are about the same as those obtained with *P. palustris* in the mountain zone.

Watershed Measurements.

In these watersheds, run-off, erosion and stream flow are being measured, together with soil moisture, soil temperature, precipitation, evaporation, etc. In the bare watershed erosion is not being measured as it is immense, and would clog all the recording instruments. It is being estimated in inches depth eroded per year.

Some facts about the bare watershed are worth noting: a week without rain means that down to 6 in. depth the soil is below wilting point; after one month without rain the wilting point is as deep as 18 in.; the temperature at a depth of 1 in. has been recorded as high as 110° F. *but* below 2 in. depth the soil so far has always had available moisture; on this bare soil a rainfall of $\frac{1}{10}$ in. causes measurable run-off.

In both watersheds a continuous record is kept of the depth of water table.

Comment.

This experimental work is in its initial stages, but it is likely to yield very valuable results which may throw light on the general water problem. Hence they are awaited with great interest, as the area is typical of so many tropical and sub-tropical regions where water becomes important in areas where vegetation has been denuded, the soil has been mined, and attempts are being made to put the forest back with conifers.

NORTH CAROLINA—COWEETA EXPERIMENTAL FOREST

This experimental forest is now known as the Coweeta Hydrological Laboratory. The object is watershed measurement—basic research for the S.E. Region, i.e. the effect of forest on climate and stream flow. The reason for the project is that originaly the engineers believed that forests had no effect on stream flow. This is largely true of navigable rivers in their lower reaches where floods or flood peaks are measured in days, weeks or months, but it is not true of the numerous small watersheds that cause these floods. In these small watersheds, floods and flood peaks are often measured in minutes or hours. In addition, it is the cumulative effect of these small watersheds that causes the silting up of the rivers, and of the dams and control works constructed in them. Thus it is largely a question of the quality of the water rather than the quantity.

The Wagon Wheel Gap Experiment started in 1915, compared two watersheds, one of which was forested, the other cleared. This was a granite soil and compared general effects without attempting to separate the components.

In Utah and California the experiments are being done on particular aspects of the problem, and with very small watersheds, and hence it was felt that intensive work on larger watersheds done in detail was necessary.

The hydraulic engineers demanded seven factors for the selection of watersheds for experimental purposes:—

(1) Deep soil.
(2) Granite origin.
(3) Dendritic pattern to the drainage (i.e. a summation of a number of independent watershed units).
(4) No deep seepage (i.e. the rock strata underneath should be impervious).
(5) Precipitation with very little snow (so that one can follow every storm with no overground storage of water).
(6) An undisturbed soil.
(7) Stable ownership.

The final selection was Coweeta.

Description of the Area Investigation Methods Used.

Area under experiment 4,200 acres. Elevation 2,200 ft. to 5,200 ft. Rainfall 77 in. (wettest month 7.2 in., driest month 3.2 in.) but very variable. Precipitation is measured by sets of rain gauges on the 5,000 ft., 4,000 ft and 3,000 ft. contours. There is a set of standard gauges which give the real distribution of precipitation. There are 13 recording gauges which give the rainfall intensity.

The rainfall varies by 40 in. from the bottom to the top of the area. The minimum recorded at the bottom is 43 in. and the maximum recorded at the top has been 165 in. so far. *But* every year 100 in. has been recorded somewhere between 3,750 ft. and 4,500 ft., so that the main experimental area is reasonably steady for rainfall. For major storms there is a constant difference of 3 in. between the bottom and the top of the area.

There are two types of storms (*a*) *summer storms*—small amounts, but of high intensity for short periods (i.e. less than 3 in. but at the rate of 5 in. to 7 in. per hour); (*b*) *winter rain*—large amounts but of low intensity (i.e. $\frac{1}{3}$ in. per hour for 30 hours). There are on an average, 128 storms per year (a storm is at least 1/100 in. rain and a break of at least six hours) and hence a lot of data can be collected in a short time. Less than 2 per cent of the precipitation is snow.

The growing season is 15th April to 15th October, i.e. two periods, six months dormant and six months growing.

The forest consists of: 77 per cent lower slopes (oak, hickory, etc.); 15 per cent cove hardwood (poplar, maple, oak, etc.); 5 per cent ridges (pitch pine *P. rigida* as a result of fire); 3 per cent higher elevations (birch, beech maple, etc.).

The average annual temperature is 55° F., average minimum 37° F., average maximum 71° F.; extremes are 93° F. and −16° F.

There are 40 independent watersheds and of these 31 are being gauged. The object is to use half as controls to compare with the other half which are treated.

There are 26 recording water wells to show the fluctuation of the water table. The water gauges are of eight different types depending on the treatment and the effect that will be produced. Flood routing is watched by artificially produced floods (by releasing water), i.e. water movement and flood waves are both measured.

The effect of treatment is compared not only with current data of the control watersheds, but also with the past data of the treated watershed.

At present, soil moisture content is not measured because automatic recording instruments have not yet reached the precision to justify the expense and extra staff involved.

Measurements.

Water Cycle.—The general hydrological formula used is:—

$$P = Ro + E + I + T \pm S$$

where:— P = Total precipitation measured by a rain gauge.

Ro = Run-off (in the American sense, and means surface run-off, and water moving through the soil, and is really the English stream flow. It is measured by stream flow gauges).

E = Evaporation (measured by an evaporimeter).

I = Interception (*a*) by the canopy, and (*b*) by the litter. It totals about 14 per cent. It is measured by rain gauges outside and inside the forest corrected for water running down the tree stems. A special litter study was also made.

T = Transpiration. (It is measured by cutting the vegetation and comparing before and after cutting in the same area and with the same control.)

S = Storage. (1) S.M. soil moisture.*

(2) G.W. ground water.*

* So far the water table has always come back to normal each year, hence this factor can be neglected in comparative studies.

Condensation of dew, etc., has not been measured, and it *might* be an important factor. Hence P T and I *might* be problematical.

General Results and Indications (with a precipitation of 80 in.).

Forest

(1) Normal

$$\left.\begin{array}{l} I = 15 \text{ in.} \\ E = 5 \text{ in.} \\ T = 16 \text{ in.} \end{array}\right\} 36 \text{ in.}$$

Ro = 44 in.

80 in.

(2) Clear Cut

I + E + T = 19 in.

Ro = 61 in.

80 in.

(i.e. + 17 in. Ro)

(3) Coppice

I + E + T = 27 in.

Ro = 53 in.

80 in.

(i.e. + 9 in. Ro)

(4) Laurel and Rhododendron Cut

I + E + T = 32 in.

Ro = 48 in.

80 in.

(i.e. + 4 in. Ro)

In the normal forest run-off consists of channel flow 5–10 per cent, and movement through soil 90–95 per cent.

Grass

$$\left.\begin{array}{l} I = 5 \text{ in.} \\ E = 14 \text{ in.} \\ T = 12 \text{ in.} \end{array}\right\} 31 \text{ in.}$$

Ro = 49 in.

80 in.

Bare Ground

E = 25 in.

Ro = 55 in.

80 in.

With grass, trampling of cattle can give channel flow 5–10 per cent, overland flow 80 per cent, and movement through soil, 20–95 per cent.

On bare ground channel flow can be 5–10 per cent; overland flow 60–80 per cent, and movement through soil 10–35 per cent.

The above neglects the *quality* of the water which is of high importance where township supplies, industries such as pulp-wood factories, or sport (fishing), etc., is a main object of management.

From a depletion/time curve a storage/time curve can be deduced, and from this the results of any storm in any area (and its flood peaks, etc.) can be predicted.

Practical Trend of the Investigation.

Watershed management tries to transfer channel flow to sub-surface flow, but this must be done in a safe and permanent manner.

There are two types of floods (*a*) due to topography, soil, etc., and these cannot be controlled; and (*b*) due to bad land use, these can be controlled by watershed management.

Typical Results from the Investigation

Land Use	*% of Area*	*% of Flood Volume*	*Comparison of % of Flood Volume*
Channel	3.15	16.20	515
Coppice	21.05	0.00	0
Cornfield	24.60	3.20	13
Upper pasture	31.20	24.40	78
Lower pasture	20.00	56.20	281
	100.00	100.00	

Thus 20 per cent of the area contributes 56 per cent of the flood volume and this is what needs to be controlled.

Erosion.—Although included in a separate section, a few outstanding facts are worth noting:—

Type of Land Use	*Sediment*
Undisturbed forest ..	2 parts per million.
Soil disturbed by intensive logging	5,000 parts per million.
Normal pasture ..	400 parts per million.
Mountain farming on steep slopes	6 lb. of soil per day per acre.
Copper Hill bare soil ..	350 cu. yards per acre per year.

The actual experimental watersheds, compared with themselves in the past and with controls, have so far given the following indications:—

Measurement of water used by vegetation: 33 acres were clear cut in 1940 and no wood products removed, hence no evaporation from exposed soil. Sprouts were cut each year. The results showed that stream flow had increased by 17 in. There was no storm peak increase, little surface run-off, but serious erosion, and the soil structure is rapidly changing. The species are also changing and slips are beginning to occur. It is definitely a very bad practice, and a crash is coming shortly and is being waited for.

Measurement of water used by the under storey.—Laurel and rhododendron were cut in 1948. The results showed that stream flow has increased by ·5 in. There was no storm peak increase, no surface run-off, no erosion, and no change in soil structure so far. So far as can be seen at present this is a safe practice. Future work here will be to cut out the rest of the species, species by species and find the progressive effect. Interactions of vegetation are apparently to be ignored.

Mountain watershed farming.—Forest was cleared and put to the local agricultural practices on steep slopes. Results have shown that corn yields have gone from 24 bushels per acre to one bushel per acre in seven years, and soil losses which started at 9 lb. per day have gone to an average of 120 lb. per day. The greatest loss was 76 tons in 35 minutes from 24 acres. It has also raised the temperature of the stream so that it will no longer hold trout.

Natural forest watershed, grazed by one cow unit for 72 acres has resulted in seriously reduced permeability, and the diameter growth of the trees has dropped off by 50 per cent.

A badly logged watershed resulted in very serious erosion.

General Comment, Conclusion and Applications

This work on the general hydrology of small watersheds as affecting large rivers in the aggregate, and of the water consumption of various types of vegetation in general can be said to have been going on for some 35 years. Even to-day we have very little precise information but a large quantity of general indications on the basis of which we can make intelligent forecasts. We know that stream flow can be increased by watershed management and in a safe manner, and that this increased stream flow can be kept reasonably pure.

It has been demonstrated that the small watersheds (which in the aggregate control the manner and quantity and quality of the stream flow in the big rivers) *must* be controlled.

Application to Tropical and Subtropical Conditions

Generally speaking, in the tropics and subtropics, this subject is of fundamental importance and yet little or no experimentation has been done, and little or no precise information is available. Here in the U.S.A. after 35 years work they are only on the fringe of the subject.

The lessons to be learned are:—

That the more tropical the conditions the greater is the importance of the subject, and the need for precise information.

The vital need for keeping a vegetational cover on the watersheds below which there are serious water problems.

In general, the comparatively small use of water made by the vegetation when compared with the total precipation. (cf. Utah and N. Carolina.)

The great danger of taking results from one country and assuming that they apply in different conditions in another country. Often figures are quoted of the effect of treatments without realizing their full effects, implications or consequences.

Perhaps the greatest lesson to be learned is from Coweeta where it has already been shown that the water from small watersheds has a value for its quantity and quality that can be expressed in actual money. Commercial concerns, townships, cities, and the ordinary citizen need this water in as large a quantity as possible, and in pure a state as possible. It is the aggregate of the water from these small watersheds that supplies their needs, and the quality and quantity of the water that they receive depends entirely on the management of these many small watersheds.

Intensive research in this subject is of the greatest importance in most tropical and subtropical countries. It will take many years before precise information can be obtained, but until this time great use can be made of the results of the work we have seen in the U.S.A. provided it is used intelligently, and with a full appreciation of the conditions under which it has been obtained. Most of the experimental work is in its early stages, and the next few years should greatly add to our knowledge of this fundamental subject.

INTERESTING FACTS ON THE PRACTICAL APPLICATION OF FOREST HYDROLOGY AND WATERSHED MANAGEMENT

In many parts of the U.S.A. the value of the watershed forests has been estimated in dollars per acre per annum of the watershed on the basis of the water only, irrespective of the value of the wood products of the forest. Many watershed forests are managed solely for their water.

Some townships have calculated the value of their water supply in dollars per acre per annum of the watershed, and actually pay the watershed owners not to cut the watershed forests. Some even go further, and realize that forest fires mean a dirty water supply. They know the cost of purification of the dirty water, and hence calculate in dollars per acre what they must afford to spend on fire protection of the watersheds.

Example of Ecusta paper pulp plant (N. Carolina). The production of this plant entirely depends on the minimum water supply. This supply comes from a watershed which is covered with forest very suitable for cutting for pulp wood for the mill. The mill, however, pays the watershed owners not to cut the watershed forest as the water is more valuable to them. They also pay for fire protection to keep the water supply clean.

The plant uses 20 million gallons of water per day. This water costs 10 cents to $2 per 1,000 gallons. At 10 cents per 1,000 gallons it costs $2,000 per day or $730,000 per year. This 20 million gallons per day comes from a watershed of 40 sq. miles. Therefore, the value of the water is $28.60 per acre of watershed per year. If the water is dirty (as a result of erosion due to fire) it costs 1 to 8 cents per 1,000 gallons to clean it for use in the plant. They can therefore afford to spend $2.86 per acre of watershed per year on fire protection.

Los Angeles (California) has a population of 4 million people and is dependent for its water on the watersheds above it. The hills are covered with chapparel scrub which is explosively combustible in the dry season (which is most of the year!). A serious fire means uncontrolled erosion for at least a year afterwards. This erosion not only dirties the water supply, but also causes mud flows which ruin fruit and farm land and invade outlying habitations.

To prevent this they spend $250,000 per year on labour for the fire protection of 1,000 sq. miles of watershed. The terrain is very inaccessible and fires are dealt with speedily by parachute squads whose supplies and reinforcements are taken in by helicopter until they can be reached by a land route.

NOTE.

Since writing these notes I have seen the draft of the "Empire Forest Terminology" which has been approved by all Empire forest departments. It shows the need for the careful use of technical terms which are often applied very loosely.

Definitions given are:—

RUN-OFF (*a*) the *total* stream discharge, including both surface and sub-surface flow, usually expressed in cubic feet, or acre/inches.

(*b*) The rate at which water is discharged from drainage area, usually expressed in cubic feet per second per square mile of drainage area (often used locally for surface run-off, a use to be deprecated).

RUN-OFF, SURFACE. The acual amount of water running off the surface of an area, not including percolation.

WATERSHED. Strictly a water parting, the dividing line between *catchment areas* (q.v.); the use of this term as a synonym for *catchment area* or *drainage* is incorrect.

CATCHMENT AREA. The total area draining into a given stream, river, lake, or reservoir. Syn. *Drainage area.* Watershed is *not* a synonym.

FACTORS AFFECTING ANIMAL NUTRITION IN TANGANYIKA*

By M. H. French

(*Received for publication on 13th February*, 1951)

The need for studying the feeding of livestock is based, ultimately, on the need for animal products to counteract deficiencies in human dietaries. That this is an urgent need is obvious to everyone when it is remembered that the 2,300 million human population of the world is showing a net increase of 20 millions per year or two extra mouths to feed every three seconds. As long ago as 1798, Malthus pointed out that the human population was increasing at a greater rate than its ability to feed itself and it is unfortunately true that the greatest rate of population increase is occurring in the less enlightened areas where the standards of agricultural production are low. A recent census has shown that less than one-third of the earth's surface is climatically suitable for crop growth and that less than 10 per cent is being cultivated. Much of the cultivated area is being used for purposes other than the production of foods. Foods from arable land may supply the fats, carbohydrates and most of the proteins required by man, but a number of accessory food constituents are needed for growth and the maintenance of health. These additional substances are largely supplied by animal products and, although the quantities of milk and meat required are not large, their effects are considerable.

Not only is there the humane need to provide everyone with an adequate standard of nutrition but, as was suggested by Lord Boyd Orr, inadequate nutrition is one of the greatest factors encouraging the spread of communism. Certainly events in Asia support this view. History repeats itself but we are slow to learn its lessons and an interesting nutritional example is that, after the first world war, Armsby pointed out that more food had to be produced and made available by better systems of distribution because "the maintenance of a food supply is the basal problem of civilization". In spite of Armsby's warnings that the U.S.A. must never again burn foods, it was only ten years later that foods were again being deliberately destroyed because of the so-called over production. This took place at a time when food production in America was lower than at any time in the previous 50 years. Even as late as 1940, when Britain was desperate for foods, the Middle West granaries were so full that producers were wondering what to do with their grain. The stage is all set for a repetition of history and it remains to be seen whether or not we are sufficiently food conscious and democratic to see that the necessary foods are not only produced but transported to the areas where they are needed.

The East African picture is a miniature reflection of the world problems. Less than five years ago pigs were being destroyed in Kenya and the Southern Highlands Province whilst to-day the pig population is being built up as rapidly as possible. Similarly, in spite of the growing demand for meat by Africans, over 200,000 cattle die annually of starvation in Tanganyika.

Just as medical activities are increasing human populations by reducing the death rates from various diseases, so is veterinary science increasing livestock populations, but with this important difference—livestock increase at much greater rates than human beings. When present policies for controlling animal diseases achieve their objectives, great increases in livestock populations will be possible, and it is necessary to plan ahead for their feeding and the utilization and distribution of their products.

There is a competition between man and his animals for the products of the soil. Whilst it is true that certain animals consume coarse fodders or the by-products of crops grown for human consumption and convert these into edible human foods, the urge to improve the productivity of livestock by the feeding of cereals and other concentrated foods increases the competition between man and his domestic stock for the limited supply of certain foods. The food value to humans of a food, such as cereal, when consumed as such is much greater than after conversion by an animal into another type of edible food. There is always a loss during conversion and, as a broad policy, the principle emerges that stock should be fed, as far as possible, on foodstuffs inedible as such by humans. There is, therefore, immediate conflict between modern trends in livestock feeding for increased productivity and the overall policy of providing everyone with an adequate diet. The only solution would appear to be the maximum use of naturally occurring and home-grown feeding-stuffs for stock and a minimum dependence on concentrates which are edible by man. This conclusion has obviously an important bearing on all animal industry research.

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* Paper read at a meeting of Veterinary Officers at Mpwapwa, Tanganyika, in January, 1951.

Because of climatic conditions, large areas of East Africa are unsuitable for the cultivation of food crops, and the keeping of livestock is then the only sound basis of land utilization. Yet it is in these particular areas that the greatest problems are, and will continue to be, encountered. It is the normal policy, in programmes of animal industry research, to increase the size and productivity of certain animal strains and to spread their progeny through the native areas. Since any increase in the potential hereditary productivity inevitably requires a higher plane of nutrition, it is necessary constantly to review improvement programmes to make certain that potential production does not outstrip the improvement in nutrition which is economically and practically desirable. We know insufficient about the large-scale improvement of grazings in semi-arid areas and it will be some time before the environmental improvements can catch up with the potential genetic improvements.

Animal industry improvement measures should therefore attempt the production of animal types which can, in the local environments, not only survive and reproduce but yield greater quantities of human food on nutritional planes which can be provided in the particular locality.

Generally speaking, native-owned stock suffer more from lack of water than from any other deficiency. Water is not normally regarded as a food but animals die more quickly from thirst than from starvation. Also, shortage of water seriously affects milk yields and can cause substantial reductions in productivity if stock are forced to walk long distances for watering. Without adequate supplies of water, over-grazing of some and under-grazing of other areas inevitably result and it is impossible to anchor the human and livestock populations to restricted areas. Unless nomadic habits are replaced by a more settled system of husbandry, it will be impossible to induce stock owners to practice the systems of fodder conservation which are so essential for and so intimately bound up with any system of livestock improvement. The provision of adequate water supplies is therefore the first step in any improved nutritional or animal husbandry programme.

Grass is the only single food on which domesticated herbivora can be maintained in health indefinitely, and it is a continuous challenge to pastoralists that more animals feed on shrubs and trees, or on plant associations in which they play an important part, than on true grass or grass-legume pastures. This is particularly true of the semi-arid regions of the territory where tree and shrub associations must continue important sources of fodder for indigenous stock for many years and at least until a change occurs in the present sociological outlook whereby mere numbers are more important than quality. No programme of improved livestock nutrition can afford to neglect the value of browse plants but much more information is needed about their yields and feeding values.

It is true that when environmental conditions permit, a greater yield of animal foodstuffs can be grown from pastures than from natural bush grazings but, owing to climatic factors over much of Tanganyika, the productivity of grazing areas is restricted by the length of the growing season. Pasture yields cannot be indefinitely increased because of this limitation but much could be done to make greater use of the forage produced during the rains. Conservation of the herbage in a more nutritious form is therefore an urgent necessity and is the most practical means for increasing the yields of animal products.

The difficulties of introducing conservation measures into native animal husbandry are fully appreciated but it is considered that this must be done. Liveweight curves of oxen on the Mpwapwa laboratory area 15-20 years ago showed dry season individual losses of up to 1 cwt. per beast and, according to the year, average losses from 25-50 lb. It was shown, at that time, that 2 lb. per head of cottonseed per day from September to the end of the dry season (December) did not eliminate weight losses in mature stock. At the same time, it was shown that if pastures were cut for hay at the end of April (when the rains ceased) the feeding value was much higher than if cutting were delayed until the beginning of June and very much higher than the feeding value of the same herbage allowed to mature and dry out *in situ* until the end of September. An examination of these figures shows that if an ox consumes a given quantity of the herbage dried off *in situ* and loses an average 50 lb. in weight, the weight loss would be more than halved if he had eaten the same quantity of herbage made into hay in June, and a gain in weight instead of a loss would have resulted if the same quantity of fodder had been made into hay early in May.

On the basis of these hay figures it can be shown that native cattle could reach slaughter weight (6 cwt.) at least two years sooner if grazings were harvested in June, and three and a half years sooner if grazings were made into hay at the end of the rains. This means that not only would existing grazing areas carry 20-35 per cent more cattle to the present slaughter weight but would produce more tender meat. Another way of expressing this is to calculate that, without any change in the numbers of animals, the potential milk yield per cow could be increased by environmental means by some 40-100 gallons per year. When feeding conditions will permit such an increase merely by haymaking there is a chance of widespread success in the distribution of stock of higher genetic milking potentialities or of producing chiller beef.

I have referred before to the need for more information on the value of browse plants. Browse plants come into leaf earlier than grasses and provide a welcome succulent addition to the diet at the end of the dry season. It so happens that these young shoots contain about twice the starch equivalent of dried-up grazings and are rich in minerals. Also the dried-up leaves are extremely useful mineral reserves earlier in the dry season and the value of browse plants can do much to eliminate the need for mineral feeding to keep pace with the greater growth rates or milk yields which haymaking will permit.

In addition to the making of hay, it should be possible to encourage pit silage which, if made from green grass during the rains, will produce succulent fodder equal in feeding value to hay made at the end of the rains. In addition, silage making from grass will allow of a nutritious aftermath growth which will extend the period of nutritious grazing.

The making of silage from cereal and legume crops is not advocated in native areas but much could be done to raise the nutritional level by the ensilage of green elephant or guinea grass grown on contour banks or in odd corners.

Other useful home-grown supplements for native stock are obtained from crop residues, but again they should be harvested and stacked immediately after the food crop has been collected. The grain stovers have feeding values equal to that of hay cut at the end of the rains whilst bean, pea and groundnut haulms have much higher values if properly harvested and stored. These leguminous residues are also rich sources of lime and provide twice the digestible protein found in grass hays.

Canna and sweet potato tops are extremely valuable dry season feeds because they are succulent and have a feeding value, equivalent to that of hay. Banana leaves, trunks and skins are further succulent materials which can be made available in certain areas, whilst there is no reason why prickly pears and other cacti should not be made to serve the dual purpose of *boma* fencing and a reserve of succulent fodder.

The problem of encouraging the use of green foods in the dry season cannot be overemphasized. Succulents usually are the equal of hay in dry matter feeding values but the provision of succulents provides a stimulus to milk production and gives beef animals a more healthy appearance. Pawpaw rinds as well as immature and over-ripe pawpaws are valuable for all classes of stock and even orange and lemon peels are relished by goats. Pumpkins and melon rinds as well as their flesh are readily eaten and provide useful feeding-stuffs whilst their seeds are rich in proteins.

Of the more concentrated foodstuffs available to native owners, mention must be made of the pods and seeds of the various acacia trees, of *Dichrostachys glomerata*, and the baobab fruits. All are rich in starch values and contain more digestible protein than dry season grazings. The residues from the grinding and winnowing of grain and from the making of native beers, rice polishings and surplus tubers or tuber rinds are useful energy suppliers. Cottonseed can and will be used but it must be admitted that, with the present world shortage of fats, the feeding of cottonseed is an inefficient method of using edible oil. In Kenya and Uganda, some African cattle owners are already purchasing oil mill residues and this practice will develop in Tanganyika.

So far the problem has been considered of existing pastural conditions but, when one remembers the large areas of bare soil and the careless manner in which abandoned cultivations are allowed to revert to weeds and thickets, it is obvious that a large field of improvement awaits development. Pasture research workers have devoted much time to the study of suitable grasses and to the methods of improving native grazing areas, but the solution of the problem is not likely to be achieved quickly. It is clear that the need for the practical application is overtaking the progress of research and it is suggested that, rather than wait for supplies of the most suitable grasses, efforts should be directed to increasing the grass cover in native areas by planting any kind of grass—even annuals. No matter what grass is used, every acre planted will add to the fodder available and in time will reduce the grazing pressure on existing stands, so that they will be able to invade the more freshly planted areas. In any case, whatever the grasses introduced, they would reduce wash and erosion and so help to raise the water table, whilst their root systems would start the necessary ameliorating effects on soil structure and fertility which must precede the introduction of the more nutritious species. The natural regeneration of vegetational communities passes through a series of stages from the primary invasion by ruderals until suitable plant nutrient conditions allow the growth of plants which require better soil conditions. To expect the more nutritious grasses, with their higher demands on soil nutrients, to establish themselves successfully when planted direct on to exhausted or eroded land is to neglect the lessons of nature. It is suggested that the less desirable and less nutritious grasses should first be used to bring the soil into a condition which will support better species and at the same time increase the fodder for livestock.

The success of such measures depends, to a large extent, on finding suitable supplies of planting material, and although propagation by cutting is a most useful measure, it is thought that any grasses which are destined to play an important part in this development must be capable of providing seed supplies in commercial quantities. Seed-producing farms are urgently required in all areas, and all cultivated land which is to be abandoned should be sown with grass seed under the last grain crop. In this connexion, many annual grasses, of good feeding value, set viable seed more readily than perennials, and it is thought that too much stress has been laid on the need to propagate perennials with a higher feeding value. It is better to have poorer stands of grass than to condone the annually recurring spectacle of patches of bare soil or weeds.

Much has been said and written of the need to plant and to encourage the growth of leguminous plants in grazing lands, but there is, so far, no clear-cut case to justify the assumption that what holds good for temperate pastures must necessarily be true for tropical and sub-tropical grazings. The problem is to get bulk and to study qualitative improvements later.

The most distressing feature of animal husbandry in semi-arid areas is the alternating periods of lush grazing during the rains and sub-maintenance subsistence during the dry season. Not only is the economy of production seriously reduced and a high percentage of the food nutrients diverted from production to maintenance purposes, but there is a strong natural incentive to eliminate high productivity in order to aid the more basic fundamental of survival of the species. The magnitude of the fluctuations is such that, except in special cases or in more favoured areas, it will be many years before it will pay to feed conserved fodders and concentrated feeding-stuffs in the dry season for other than the maintenance of the liveweight gained during the rains. In the same way, the bulk of the milk produced should be from wet season grazings, although attention should also be given to the dry season production of sufficient milk for family purposes. This may seem a defeatist policy, but it is better not to aim too high when dealing with changes in traditional husbandry practices and it is better, when introducing new systems into African procedures, to attempt a level of improvement which can be achieved with certainty than to fall short of a much more laudable objective.

In the previous remarks, I have deliberately refrained from any mention of minerals, yet there are many areas where the mineral intake is dangerously near deficiency levels and any marked improvement in milk production will certainly lead to mineral shortages under the existing nutritional levels. Therefore, every encouragement should be given to the continued use of natural licks. It is true that many of these so-called "salt-licks" can be of little value but others can supply lime and phosphates as well as salt. It is interesting therefore to see how the measures previously recommended are likely to supply the mineral needs of livestock. Cutting grass and conserving it as hay or silage will enable a higher intake of lime, phosphate, sodium and chloride to be obtained than if the fodder dried off *in situ*. This is also true of crop residues, the reason being that plant minerals migrate from the vegetative parts to the roots if the plants die off *in situ*. The greater use of residues from leguminous crops will add appreciably to the lime and potash intakes whilst supplying adequate amounts of phosphates. Grain stovers are relatively rich in potash, soda, and chloride and contain a fair supply of lime. Tree pods and seeds contain good supplies of phosphate and lime, whilst the leaves of browsing plants are rich in both. By-products of cereals and of oil-mills are rich in phosphates and reasonably well supplied with lime.

It will be seen therefore that on the suggested lines of nutritional development there will be normal supplies of lime, but phosphates may be insufficient for optimum lactation and growth. Chlorides may also be in short supply and will be needed for heavier milking cows. There would appear no cheap source of phosphate for use in native areas, because existing ideas on the selling price of bone meal puts this phosphatic supplement beyond the means of most natives. Whilst it may be desirable for packing-houses to show immediate profits it is certainly wrong from a long-term territorial aspect to allow the export of phosphates. The provision of salt will also cause difficulties because the natives themselves are short. Adequate reserves of salt are at hand in the Rift Valley Lakes and the Indian Ocean and salt production should be encouraged. As a means of meeting livestock needs is the possibility of burning swamp grasses (i.e. Papyrus) and feeding the ash.

Mineral deficiency diseases have attracted much attention this century and it may be of interest to summarize the position in Tanganyika. There is no evidence of a straight calcium deficiency, although low lime values have been reported in certain grazings in the Iringa, Njombe and Bukoba lacustrine areas. Fragility of bones and eroded teeth are known to occur in the Engare Nanyuki-Oldonyo-Sambu area but here the possible explanation is that the highly alkaline waters from the mountain streams interferes with calcium absorption in the alimentary tract. Lime feeding is generally advantageous for poultry, pigs and milking cows. Sodium, potassium and chlorine are low in many pastures and the feeding of salt in such areas as Njombe, Iheme, Dodoma, Nzega and Bukoba will be beneficial. So far as I am aware, there are no evidences of a "lecksuct" due to specific sodium or chlorine deficiency although, in hotter countries, Peck has reported the need for feeding salt to camels to prevent skin troubles. It is also thought that although certain grazings are low in potassium the shortage is not sufficiently acute to cause deficiency symptoms in grazing animals.

Typical symptoms of osteoporosis and osteomalacia have not been reported nor are there records of any osteophagia in Tanganyika. On the other hand, there is evidence from blood phosphorus surveys that, in Bukoba, Njombe, Iringa, Engare-Nanyuki, Oldonyo-Sambu, Singida, Tabora, Shanwa, North Mara and Lushoto, young and lactating native stock will benefit from phosphorus supplements. In other areas which supply sufficient phosphorus for Zebu animals, supplementary phosphate feeding is necessary, if low blood levels are to be avoided, when higher producing grade cattle are being kept.

Iron, cobalt and copper deficiences have attracted much attention during the last 20 years but there is no direct evidence that these elements are causing trouble in Tanganyika. On the other hand, the higher altitude anaemias and the widespread dry season anaemic conditions, coupled with the fact that "Enzootic marasmus" from straight cobalt deficiency occurs in the Nakuru area, makes it necessary for a further examination of the cobalt status to be made. The evidence is that the usual drop in hæmoglobin during the dry season in the Mpwapwa and Engare-Nanyuki areas is not due to a shortage of either of these elements, but further study may disclose evidence of cobalt deficiency especially in the sandstone, coral and volcanic regions. The emaciation, unthriftiness, lack of appetite and the stiff gait of certain high grade animals in low altitude areas is suggestive of copper deficiency as is also the hindquarter weakness, almost amounting to an ataxia, in lambs. "Ol Mori", a wasting disease recognized by the Masai and characterized by inanition and emaciation, particularly of the gluteal muscles, may also be associated with copper deficiency. I stress again that I have no conclusive evidence that shortage of these minerals causes pathological conditions in Tanganyika and the possibilities mentioned need further examination.

The only metabolic disturbance caused by a mineral excess is, so far as I know, fluorosis in the Engare-Nanyuki area.

Before leaving the problem of deficiency diseases I would like to refer briefly to vitamins. Shortages of vitamins A, D, E and the B group can be encountered in housed pigs. The position regarding the vitamin A status of herbivora during the dry season needs examination, particularly in view of the dependence of the vitamin level of milk on the available supplies or liver reserves. It is possible that both vitamins A and E are approaching or may reach deficiency levels at the end of a long dry season and that the demands by European and Zebu stock may be different. Of the B group, I would suggest further attention should be paid to B12 and Folic acid supplies of cattle in the dry season and their possible relationship to the dry season anaemias.

I have attempted to survey the nutritional problems associated with native-owned stock, and have tried to indicate how the nutritional level generally can be raised without drawing on foodstuffs which can be consumed as such by man. My suggestions are:—

(*a*) Improvement of water supplies.
(*b*) Planting of grasses on bare areas and on exhausted cultivated lands.
(*c*) The adoption of fodder conservation measures such as hay and silage making.
(*d*) A better utilization of crop and household residues, succulent foods and the seeds and pods of certain trees.
(*e*) An extension of the period of green grazings into the dry season by the encouragement of aftermaths in the early period and the browsing of the green leaves of trees and shrubs just before the rains.
(*f*) The provision of phosphate and salt in those areas where there are suggestions of inadequate supplies and a better utilization of foodstuffs rich in mineral matter.

REVIEWS

INDUSTRIAL FIBRES, 1949, obtainable from H.M. Stationery Office, or from the Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, London, S.W.1. Price 5s. 0d. (5s. 3d. post free).

The Commonwealth Economic Committee's review of industrial fibres traces the post-war trends in production and consumption of the chief fibres and serves as a background to the current position of general scarcity. The extent to which prices by November, 1950, had risen above pre-war levels may be seen from the following index numbers of United Kingdom prices (1934-38 = 100): Cotton, 709; merino wool, 842; crossbred wool, 1,092; jute, 612; sisal, 845; rayon, 177. Since that date all fibres, as the Committee comments, have shown further sharp price increases.

In 1949-50 the output of every fibre except jute increased and a considerable surplus of cotton, which normally accounts for over half the total production of fibres, was anticipated for 1950-51, the area under cotton in the United States, was therefore restricted in 1950-51. The American crop, which totalled less than 10 million bales compared with over 16 million bales in the previous season, was smaller than had been expected, and exports are at present restricted on a quota basis. Despite increases in many other countries, world output for 1950-51 is estimated at 13 per cent less than in 1949-50. But the withdrawal of American acreage restrictions should lead to a substantial increase in output next season.

Wool production continued to rise in 1949-50. Output in most of the producing countries (with the notable exception of the United States) was greater than in 1948-49. Nevertheless consumption in 1949 and 1950 exceeded output by some 10 per cent and Joint Organization stocks were again heavily drawn on.

Rayon production was 41 per cent higher in 1949 than in 1938, and rose further in 1950. Production in 1949 was, in fact, almost 500 million lb. greater than world wool production in 1949-50 (clean basis). But the level of output is still below the demand for rayon in its textile and industrial uses, and the shortage of raw materials such as sulphur may hamper further expansion. The output of silk was drastically reduced during the war and in 1949 was only 29 per cent of the 1938 total. Although rayon and nylon have become established in some of silk's former uses, the indications are that silk consumption is still limited by supply, and output was increased in 1950. Flax and hemp production continued to expand in 1949, but the output of jute fell because of the reduction in the Pakistan crop. In 1950, however, both India and Pakistan increased their jute production.

In the post-war period, as before the war, the Commonwealth produced virtually all the world supply of jute, almost half of the wool and about one-tenth of the rayon. The Commonwealth share in hemp production rose notably from 21 per cent before the war to 30 per cent after 1945, but the proportion of cotton fell from 18 per cent to 13 per cent, largely because of the reduced Indian output.

A study of world trade in industrial fibres shows that it rose in 1949 but was still below pre-war. The United Kingdom remained the chief importer, taking larger quantities of wool but smaller amounts of other fibres than in 1938. Imports into Western Europe and the United States were in general larger than before the war, mainly because of the increased shipments of wool to these countries. Japan, however, which was the second largest importer in 1938, took only one-third of the pre-war quantity in 1949.

WORLD CONSUMPTION OF WOOL, 1949, obtainable from H.M. Stationery Office, or from the Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, London, S.W.1. Price 5s. 0d. (5s. 3d. post free).

Although world production of raw wool is expected to increase, the available supply in 1950-51 is expected to be ten per cent less than the annual rate of consumption attained in the first half of 1950, according to the above review published by the Commonwealth Economic Committee. It is estimated that world consumption in 1950 will have recovered fully from the decline which occurred in 1949 and will reach a peak level of more than 2,600 million lb. (clean) owing primarily to the recovery in United States' consumption; but since supply stocks held by the Joint Organization and the United States Government are nearly exhausted, it is likely that total consumption in 1951 will show a significant fall, compared with 1950. The increased use of substitute materials such as shoddy and synthetic fibres may ease the position to some limited extent; nevertheless, if defence requirements are to be met, a substantial reduction in civilian consumption of wool seems inevitable.

"World Consumption of Wool, 1949" contrasts the period 1946 to 1949 with pre-war, and outlines the developments in world wool consumption which have led up to the present situation. Details are given of consumption and industrial output in the wool textile industries of all the major consuming countries together with statistics of each country's trade in raw wool and wool manufactures. Activity in the world's wool textile industry declined quite appreciably in 1949 for the first time in the post-war period. Wool consumption was nearly eight per cent less than in 1948, while the reduction in the output of tops was 13 per cent, in yarn three per cent and in tissues five per cent. Since the war the United States has dominated world activity in wool and any large change in its output has accordingly affected the world total. This was clearly apparent in 1949 when the United States experienced in the first six months of the year a significant fall in industrial activity; although a recovery began in the second six months the consumption of wool and the output of wool goods during the year showed a sharp decrease in comparison with 1948. In France, Belgium and Italy, industrial output followed the broad pattern set by the United States. By contrast, wool consumption and the output of textiles in the United Kingdom and Germany continued their post-war recovery, though the increase was insufficient to offset the decline elsewhere. In 1949 the United States just failed to retain the position reached in other post-war years as the world's largest consumer of wool, the United Kingdom taking first place for the first time since the beginning of the war. The United Kingdom also regained its pre-war position as the world's largest producer of tops and worsted yarn.

Although the consumption of raw wool by Germany and Japan (two important pre-war consumers) in 1949 was substantially less than before the war, world consumption was estimated as being 14 per cent heavier than in 1934-38. Notwithstanding this significant increase, world production of tissues was still fully five per cent less than before the war, while the output of tops and yarn was also below the 1934-38 average.

Foreign trade in tops, yarn and tissues during 1949 was virtually back to its pre-war level, despite the continued absence of Germany and Japan. The United Kingdom became by far the largest exporter of tops, exporting much more than before the war, but shipments from France and Belgium were appreciably below pre-war levels. France. however, exported a much larger quantity of tissues than before the war and, as in 1948, ranked second to the United Kingdom as an exporter.

THE ROOT SYSTEMS OF SOME BRITISH SOMALILAND PLANTS—III

By P. E. Glover

(*Received for publication on 1st February, 1951*)

SHRUBS

Acacia misera Vatke, vernacular "Khansa" (Diagram 23).

Vegetation type No. VII: Haud sub-type *Acacia* tree and shrub.

Locality: Guban, Ged Dobo. Latitude 10° 7′ 30″ N. (approx.), longitude 45° 12′ 30″ E. (approx.); altitude 1,900 feet.

Annual rainfall: Eight to ten inches (Hunt, 1945).

Acacia misera Vatke is a common, large, thorny shrub in most parts of the country from the Guban to the Haud, and has an altitude range from 1,000 feet to 4,000 feet. It flourishes on sites of prolonged devastation and sometimes forms almost "pure stands". Good examples of this can be seen a few miles to the west of Odweina, and in parts of the Haud. The plant may grow to a height of 3 or 4 metres, and have an equal crown diameter measurement. It has a very well developed shallow lateral root system. It was noted in several instances that the tap-root tapered down suddenly from a thickness of 7 or 8 cm. at ground level to 2 or 3 cm. at a depth of 30 or 40 cm. In the Guban this plant seemed to prefer stony or coarsely gravelly soil.

The plant examined was 3 metres high, had a crown diameter of 3.5 metres and showed signs of having been severely cut from time to time. Its tap-root was 7.5 cm. thick at ground level and was covered with a dark brown, gnarled-looking bark. The main root and many of the lateral roots went straight down into the soil, but three strong ones struck out in different directions horizontally, between 25 and 30 cm. below the soil surface. These three roots had an overall lateral extent of 18.6 metres and grew right through a clump of *Salvadora persica* L.

Diagram 23 shows a horizontal dissection of the lateral roots. Secondary rootlets have not been included in the drawing. Note the clockwise twist to the roots.

The first 15 cm. of soil was fairly fine grained, micaceous alluvium, but from there downwards it was a very coarse gravel with large pebbles in it.

The leaves and young shoots of this plant are grazed by stock especially camels, although it is very thorny. The Somalis put it to a variety of uses. The bark is used for making rope and the roots are used in the lattice work of "gurghis" or Somali huts.

Acacia sp., vernacular "Sarman Jif-Jif" (Diagram 24).

Vegetation type: As for *Acacia misera* Vatke.

Locality: As for *Acacia misera* Vatke.

Annual rainfall: As for *Acacia misera* Vatke.

This plant is common in the Guban and in the Haud and has an altitude range from 100 to 3,000 ft. In the Guban it often forms a skirt on loose, stony soil at the foot of hills. In the Haud it takes part in one of the successional stages following bush fires and other types of devastation. It is a short, flat-topped, thorny shrub which seldom grows to a greater height than 3 metres. The specimen examined was 1.5 metres high, had a crown diameter of 4 metres, with a tap-root 11 cm. thick at ground level. It was growing in loose, stony soil.

Its tap-root tapered down abruptly in the first 30 cm. below the surface, though it may have gone down very deep. However, it seemed to concentrate on lateral roots which formed a considerable system with an overall extent of 39 metres. The main laterals came off the tap-root at right angles at depths varying from 3 to 30 cm. and grew out horizontally.

The three main lateral roots shown in figure 24 had diameters of 3.5 cm., 4 cm. and 4.5 cm. at their junction with the tap-root. They all came off at different points at a depth of 3 cm. and extended laterally for 27, 19 and 25 metres respectively, then their ends turned and went downwards into the soil.

The fresh shoots, green leaves and fruits of this plant are grazed by stock, but it is very thorny, and in the dry season is hard and tough.

Acacia socotrana Balf. f., vernacular "Jerin" (Diagram 25).

Vegetation type: As for *Acacia misera* Vatke.

Locality: As for *Acacia misera* Vatke.

Annual rainfall: As for *Acacia misera* Vatke.

Acacia socotrana Balf. f. is widely spread throughout the country, and has an optimal altitude range of 1,000 to 4,000 ft. It is a low-growing, elliptical shrub sometimes up to 10 metres in diameter and 1 to 1.5 metres high. It is often found in sandy places and in places that have been severely over-grazed for a prolonged period. Because of its low-growing habit it is an extremely good binder of wind-blown sand. (Often a plant may be seen nearly covered in a round sand mound.) Almost pure communities of the plant occur on sites which must have once been practically denuded. A good example of this can be seen at Jerinle a short distance out of Burao on the Burao-Duruksi Road.

The plant examined at Ged Dobo was 60 cm. high, with a canopy width of 1.8 metres. The tap-root was 6 cm. thick at the soil surface and tapered to 1 cm. at a depth of 1 metre. The overall development of the lateral roots was 13.25 metres. The tap-root divided into three main roots at 2.2 metres and one main root was traced to a vertical depth of 6 metres where it had diminished to a thickness of 2 mm., but was still going downwards. Unfortunately the pit had been constructed in such a way that the sides were beginning to fall in and it became dangerous to continue further. (Also all the workers were suffering from severe urticarial burns on their exposed arms and legs, the cause of which was unknown, but was noted in no other area.)

At the base of the plant was a sand mound 20 cm. high and 70 cm. wide. One large lateral root and several smaller ones emerged from the main root and went out horizontally at a depth of 20 cm. below the top of the mound. Diagram 25, figure 1, shows that almost all these lateral roots curve upwards and downwards to accommodate themselves to the contours of the soil and maintain a more or less constant distance of 5 to 10 cm. below the surface.

The secondary rootlets coming off these lateral roots sometimes reached to within 2 or 3 mm. of the surface. Another lateral which branched off at 1.50 metres, went into the face of the wall after continuing horizontally for 75 cm.

Between the depths of 2.1 and 2.2 metres, the main root split into 3 large branches which curled and twisted about in a horizontal plane for 90 cm. and then continued straight downwards to a depth of 4.4 metres where much curling and twisting took place again in the central root. The left hand root, after turning to the left horizontally for 15 cm. at a depth of 4.5 metres, petered out, but the right hand one after curving and twisting at a depth of 4.8 metres, continued horizontally to the right for 30 cm., turned straight down for 50 cm., then curved upwards again for 20 cm. and divided into five roots which all reversed into the wall.

The central root continued downwards along an uneven course to a depth of 5 metres. From there it went almost straight downwards for 60 cm. After that it curved to the left and continued in the same direction for 40 cm. and then downwards to a further depth of 10 cm. Then it split into two, one of which reversed into the wall, while the other curled and twisted towards the left for 10 cm., then continued to go straight downwards again, but was only traced for a further 10 cm. in this direction.

The soil from the top of the sand mound was a loose, fine-grained, grey sand for the first 50 cm. down. From there to a depth of 1.7 metres was a layer of highly micaceous, fine-grained, grey, sandy soil, in which the visible moisture penetration lines could be clearly seen a few hours after rain. From 1.7 to 2.1 metres beneath the surface was a layer of coarse, red, highly micaceous gravel. This gave place to a layer of very hard, dark grey, gravelly soil, containing white saline matter, which may have been gypseous. It continued to a depth of 2.8 metres. Then a greyish, gravelly sand appeared which was replaced at 3.2 metres by a very coarse, gravelly sand to a depth of 3.4 metres. This in turn gave place to a less coarse, grey, gravelly sand down to 3.7 metres where a fine, grey sand with some gravel reappeared. At 4.1 metres a layer of very fine sand 20 cm. thick appeared. Then came a layer of fine, grey, highly micaceous clay with some gravel grains in it. A very hard, fine, grey sand 15 cm. thick came next with many dead root ends in it. From 5.5 metres to a depth of 6 metres where operations ceased, the soil was a fine, moist, micaceous sand with much dead root material in it.

Reference to Diagram 25, figures 1 and 2, shows that *Acacia socotrana* Balf. f. had an extremely well developed, lateral root system within the first 20 cm. of soil which enabled it to make use of moisture from light showers that did not penetrate deeply into the soil. Also in contrast to many other *Acacia* spp., it had a very well developed, deep root system.

so that it was not entirely dependent on its shallow lateral roots.

Zones of much root activity were found within the sandy soil layers for the first 20 cm. and the first 20 cm. of the very hard, clayey layer which appeared at a depth of 2.1 metres, but the zone of greatest activity was between the depths of 4.3 metres to 5.3 metres in which there were alternating layers of fine sand, clay, hard fine-grained sand and very fine, moist, micaceous sand.

It would seem from this, that layers of clay, hard soil, or tightly compacted gravel, act as barriers which retard root penetration, but induce lateral development in the main vertical roots.

The main roots were a dirty white colour, tough and fibrous. Secondary lateral roots were numerous throughout and on them were bacterial nodules which, when examined, were found to be almost identical with those of *Indigofera ruspoli* Bak. f. (i.e. they were made up of fairly tightly twisted bunches of enlarged root hairs). Also the secondary lateral filamentous roots seemed to be covered with a fine layer of a gummy exudate to which soil particles adhered. (See diagram 25, figure 3.)

The younger aerial shoots of *Acacia socotrana* Balf. f. are relished by stock, especially camels. A close inspection of any plant of this species almost invariably shows numerous scars on the short branchlets where the younger shoots have been grazed off, season after season. It was observed at Ged Dobo, that if the younger shoots were not grazed off as soon as they appeared after rain, they grew in the initial stages at a rate of 5 cm. in three days.

Acacia socotrana Balf. f. seems to be very resistant indeed to over-grazing and trampling and throughout the whole country, not one dead plant from this cause was seen. Although the young shoots are much sought after by stock, its many short, stiff branchlets give protection to the inner leaves and shoots, which during the dry season are hard, tough and unpalatable.

Blepharispermum fruticosum Klatt. and Schinz, vernacular "Gahait" (Diagram 26).

Vegetation type No. VIII: Haud, *Commiphora acacia* tree, shrub and grass.

Locality: Haud, Alablah. Latitude 8° 2′ N. (approx.), longitude 45° 1′ E. (approx.); altitude 2,500 feet.

Annual rainfall: Between 6 and 8 inches (Hunt, 1945).

Blepharispermum fruticosum Klatt. and Schinz, is a very common Haud shrub which may reach a height of 1.5 metres. Its optimal altitude range is between 1,500 ft. and 3,000 ft. and unlike many other Somaliland plants, it appears to be fire resistant, thus it often forms almost pure stands on areas that have had all their large trees killed out by fire.

The plant examined at Alablah was 95 cm. high and had a crown spread of 65 cm., made up of a number of stems each of which had its counterpart in a root beneath the soil. Its overall lateral root spread was 6.1 metres and its vertical penetration 1.7 metres. Many of the profuse, stout, grey-brown fibrous roots went out horizontally a few centimetres below the surface. Some of them, after curving out sideways, went down in a more or less vertical direction. A few were dead near the tips. The growing points were white, the rest of the roots were brown-grey. There were numerous secondary rootlets branching off the main roots.

The soil was a yellow-red, loose sand for about 50 cm. with a certain amount of organic matter in it. From there downwards it became more closely packed, lighter in colour and had numerous pebbles and sometimes artefacts in it. At 75 cm. beneath the surface, lumps of loose, white, decomposed limestone appeared and at 1.10 metres a solid layer of decomposing, white shaley limestone was found. The zone of maximum root activity was from just below the surface to a depth of 75 cm.

A few large roots penetrated into the limestone but could not be traced further.

The leaves and young shoots of *Belpharispermum fruticosum* Klatt. and Schinz are grazed by all stock and when crushed between the fingers they have a scent reminiscent of mangoes.

Entada flexuosa Hutch. and Dalz., vernacular "Faradere" (Diagram 27).

Vegetation type: As for *Blepharispermum fruticosum* Klatt. and Schinz.

Locality: 4½ miles south of Alablah.

Annual rainfall: As for *Blepharispermum fruticosum* Klatt. and Schinz.

Entada flexuosa Hutch. and Dalz. is fairly common in parts of the Haud. It is conspicuous by its large compound leaves and striking flat segmented fruit pods which are sometimes 30 cm. long and 10 cm. wide. The plant is made up of a number of long flexible stems and grows in open places where it takes the form of a scandent shrub, or in thickets where it assumes the role of a climber.

The specimen studied at Alablah was growing in a fairly open site. It was 90 cm. high and had a crown diameter of 1.2 metres in one direction and 4.5 metres in another. Its roots penetrated the soil at a maximum depth of 60 cm. (Diagram 27, figure 1, shows a horizontal dissection of the root system and figure 2 shows a vertical view of it.)

The roots were thick, fleshy and constricted at intervals along their length. Some of them were 10 or 12 cm. thick in places. Almost all the root activity was confined to the first 50 cm. of soil. Many of the roots went out horizontally only 1 or 2 cm. below the soil surface. They were reddish-brown in colour on the outside, red on the inside and contained sticky red sap. Bundles of thick fibres were embedded in the soft fleshy parts of these roots. The lateral roots had a decided clockwise twist around the centre.

The soil was brick red and sandy from the surface to a depth of 50 cm., after that it became a darker red in colour, clayey and so hard that it was almost impossible to dig, even with a pick.

The roots of *Entada flexuosa* Hutch. and Dalz. are much sought after in the dry season by the Somalis as a substitute for water for their stock and they claim that camels can be kept alive for weeks with no other liquid than the juice from these roots. The leaves and young shoots are grazed by all stock. The roots are not fit for human consumption as they have a very unpleasant astringent taste.

Erythrina rotundato-obovata Bak. f., vernacular "Yo-Oh" (Diagram 28).

Vegetation type: As for *Blepharispermum fruticosum* Klatt. and Schinz.

Locality: As for *Blepharispermum fruticosum* Klatt. and Schinz.

Annual rainfall: As for *Blepharispermum fruticosum* Klatt. and Schinz.

Erythrina rotundata-obovata Bak. f. is a frequent shrub in the Haud, especially on the edges of the plains. It is many-stemmed and may reach a height of 3 metres. Its presence on the edges of plains is probably due to the fact that it is fire-resistant.

A plant examined at Alablah on the edge of a small plain was 1.3 metres high and its crown diameter was 80 cm. It had a lateral root spread of 12.3 metres in one direction, 13.7 metres in another and 5 metres in a third direction. The roots penetrated the soil to a depth of 1.4 metres. They were studied in both the vertical and horizontal planes. (*See* diagram 28, figures 1, 2 and 3.)

Below ground level, all the stems came together in one large gnarled base from which emerged a thick tap-root. This went straight down for about 65 cm. and then branched into three main roots, which went off in different directions laterally. The tap-root was 10 cm. thick at its junction with the stem base. The largest main root was 7 cm. thick at its point of origin. The soil became very hard indeed at a depth of 65 cm. All three of the main roots, after penetrating the hard layer for a short distance, curved upwards again and approached the surface of the soil.

The light brownish-grey coloured roots were very thick and fleshy almost to their tips. In fact several of them ended in thick blunt stumps. (*See* diagram 28, figures 2 and 3.)

The soil was light red and sandy down to a depth of 30 cm. From there it became harder, and at 1 metre it became so hard that it was difficult to dig away and obviously hindered root penetration, hence the reason for the gnarled blunt-ended roots mentioned above.

The roots contain an appreciable amount of good, not unpalatable liquid and during times of drought the Somalis chew them as a substitute for water.

The plant has numerous stout, claw-like thorns on its stems, branches and leaf raches, but in spite of this its leaves and young shoots are grazed by stock.

Iphiona rotundifolia Oliv. and Hiern., vernacular "Gegabod" (Diagram 29).

Vegetation type: *Balanites* and *Maerua*, coastal shrub, *Acacia* grass and desert scrub.

Locality: Zeilah Plain, two miles N.E. of Silil. Latitude 10° 59′ N. (approx.), longitude 43° 22′ E. (approx.); altitude 200 feet.

Annual rainfall: 4 to 6 inches (Hunt, 1945).

Iphiona rotundifolia Oliv. and Hiern, is locally common in many parts of the country. It has an altitude range from sea level to 3,500 feet and occurs in the Guban, on the Central Plateau and in the Haud. It ranges in height from 20 to 60 cm. and may equally well be called a woody herb as a shrub.

The plant examined at Silil was 30 cm. high by 20 cm. wide and the tops of its roots were exposed for 10 cm. above ground. It had an overall lateral root spread of 3.8 metres and a vertical penetration into the soil of 4.6 metres.

The roots were black in colour and tough and fibrous with a hard, outer sheath, but became very brittle near their tips. There were very few secondary rootlets. The plant had one large, thick main root which went almost straight into the soil for 1.3 metres, then it branched into two, one of which went off horizontally to the right at a depth of 1.53 metres. At a depth of 40 cm. a large root branched off the main one, went off to the left and proceeded sideways and downwards in steps to a depth of 4.5 metres, then it turned to the right and continued horizontally for 70 cm. and finally went into the wall. Between 3 metres and 3.8 metres it sent off several branches some of which continued downwards to 4.3 metres and then petered out. Between the soil surface and a depth of 60 cm., several lateral roots came off the main root and grew out in a horizontal direction.

The soil was a medium fine loose alluvial sand down to a depth of 60 cm. where it became hard and compacted. Between the depths of 1.3 and 1.8 metres, it was made up of layers of dark clayey mud rich in organic matter alternating with layers of fine-grained moist sand. From there down to 3.2 metres, it was made up of layers of sand of varying texture. At 3.3 metres a dark, heavy, clayey mud layer appeared again which continued down to 4.1 metres. From there down to 4.5 metres there was a fine moist sand, then a layer of dark, heavy, clayey mud was met again. In every case the zones of greatest root activity were between the layers of heavy mud.

The roots of another specimen of this plant were examined at Ged Dobo, in a similar type of soil. It was 45 cm. high and 30 cm. wide and sent out four lateral roots 2 to 3 cm. below the soil surface for a distance of 60 cm. The ends of all these roots had died off. The plant had a main root 1 cm. thick at the soil surface which went straight down to a depth of 92 cm. where it was found that the rest of it had died off and disintegrated. In the same way as the plant at Silil, this one had very few secondary rootlets and its main roots had a black, hard outer casing.

The leaves and young shoots of *Iphiona rotundifolia* Oliv. and Hiern are grazed by all stock and the Somalis make a concoction of the roots with milk, which they drink as a purgative.

It is not unusual to see plants of this species almost completely covered with wind blown sand, or with 10 or 15 cm. of their roots exposed, for which they do not seem any the worse. The plant appears to be very resistant to trampling and over-grazing.

Salsola foetida Del., vernacular "Gulan" (Diagram 30).

Vegetation type: As for *Iphiona rotundifolia* Oliv. and Hiern.

Locality: 7 miles N.E. of Silil. As for *Iphiona rotundifolia* Oliv. and Hiern.

Annual rainfall: As for *Iphiona rotundifolia* Oliv. and Hiern.

This plant is widely spread throughout the country on sandy soils which are saline. Its altitude range is from the water's edge at sea level to 3,500 ft. It is a plant which could as well be called a shrub, as a woody herb. Sometimes, as in the grazing reserve at Burao, it may grow to a height of 1.6 metres with a width of 2.2 metres. The plant examined near Silil was 50 cm. high and 1.2 metres wide.

The tap-root was 2 cm. thick at ground level. The lateral roots had an overall spread of 6.4 metres and the vertical ones penetrated to a depth of 5.2 metres. One root continued downwards but it was not possible to trace it further. The tap-root divided into three stout main roots between 7 cm. and 20 cm. down. The central one went off into the wall and the other two continued more or less straight downwards to a depth of 2.4 metres, when the left-hand one gave off a branch which continued downwards for 20 cm. then went off horizontally to the left. At 4.1 metres beneath the surface, it again gave off a branch which went out horizontally to the left for a distance of 1.6 metres when it branched into two, one of which continued horizontally for a further 3.8 metres, then petered out. The other went downwards for 70 cm., then horizontally to the right for 75 cm., then downwards again for a further 40 cm. After that it turned outwards under the floor of the "tug" in the wall of which it had been growing. When it had given off this branch the main root turned slightly to the right and gave off another finer branch which continued more or less straight downwards for 1.2 metres. At 4.3 metres the main root turned and grew out horizontally to the left for 90 cm. and then went off into the wall. The roots of this plant were a dirty grey in colour with a crinkly outer casing. There were very few secondary filamentous rootlets.

The soil was built up of layers of varying textures of sandy alluvium to a depth of 70 cm., where a thin layer of heavier, more clayey mud was reached. This gave place to sandy layers to a depth of 2.6 metres. From there on, heavy clayey mud layers of varying thicknesses occurred at 3, 3.6 and 4.2 metres. From 4.6 metres downwards the soil was built up almost entirely of layers of heavy clayey mud.

In this case also the zones of lateral root activity almost invariably coincided with the top of the layers of clayey mud. At 3 metres beneath the surface the soil became fairly moist.

Salsola foetida Del. is grazed by all stock and the Somalis claim that it is rich in salt. In some parts of the country where there is much *Salsola foetida* Del. the places are known as salt grazing areas, e.g. Dambare, east of Burao. The local Somalis bring their stock to these places at certain times of the year and claim that by so doing they eliminate the necessity for a salt lick.

Secamone punctulata Decne., vernacular "Geseriad" (Diagram 31).

Vegetation type: As for *Iphiona rotundifolia* Oliv. and Hiern.

Locality: As for *Iphiona rotundifolia* Oliv. and Hiern.

Annual rainfall: As for *Iphiona rotundifolia* Oliv. and Hiern.

This plant is very common locally in the sandy alluvial soils of the Guban. It is a small herbaceous shrub which may reach a height of 80 cm. and a width of 1 metre.

The specimen studied at Silil was 45 cm. high and 60 cm. wide. Its tap-root was 2 cm. thick at the soil surface. It had an overall lateral root spread of 5.2 metres and vertically its roots penetrated the soil to a depth of 4.4 metres.

This plant was examined a few feet away from the specimen of *Iphiona rotundifolia* Oliv. and Hiern. The soil was the same (i.e. the first 20 cm. were a medium, fine, loose alluvial sand, etc.). In this case, as in that, the zones of greatest root activity coincided with the tops of layers of heavy, dark, clayey mud rich in organic matter, or zones of tightly compacted hard sand.

The roots were whitish with a soft, fleshy outer casing. There were numbers of secondary filamentous rootlets towards the ends while the roots themselves became brittle and broke easily near their tips.

The plant is grazed by all stock.

CONCLUSIONS

From the above descriptions and diagrams the following conclusions may be drawn:—

(1) *Acacia misera* Vatke and *Acacia* sp. "Sarman Jif-Jif" had very extensively developed lateral root systems.

(2) *Acacia socotrana* Balf. f. while having a good lateral development also had a well developed deep root system.

(3) *Acacia misera* Vatke and *Acacia* sp. "Sarman Jif-Jif" had shallow, lateral root systems and seemed to prefer stony or gravelly soil in the Guban, while *Acacia socotrana* Balf f. appeared to thrive in deep, sandy soil.

(4) *Entada flexuosa* Hutch. and Dalz. and *Erythrina rotundato-obovata* Bak. f. had extensively developed, shallow, lateral, succulent root systems. This shallowness was largely because the soil in which these two plants grew became very hard at depths varying from 30 cm. to 90 cm.

(5) *Iphiona rotundifolia* Oliv. and Hiern, *Salsola foetida* Del. and Secamone punctulata Decne. had extremely well developed lateral and deep root systems in relation to the size of the plants. The roots were characteristically thick and tough.

(6) In the sandy soils of the Guban layers of tightly compacted soil and heavy muddy clay appear to retard vertical root penetration and promote lateral development.

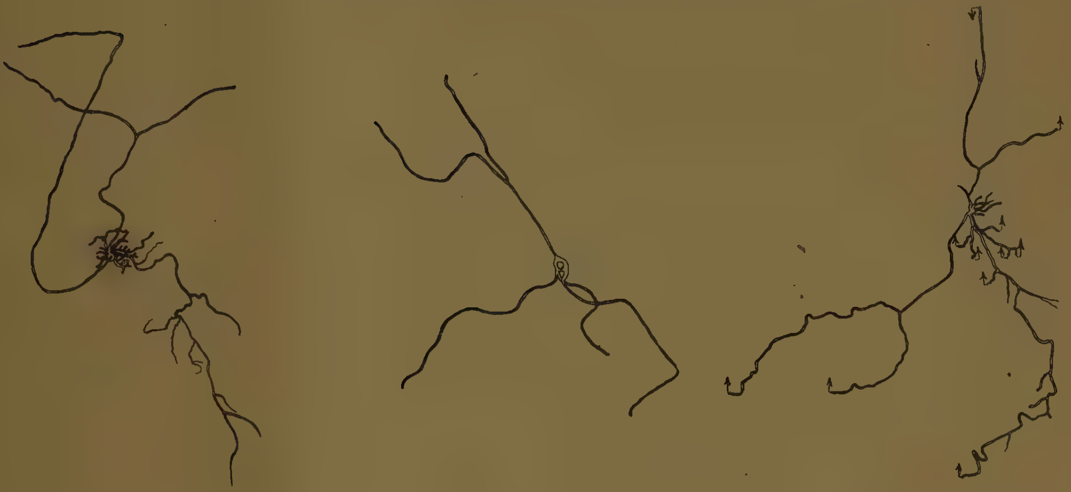
(7) Plants growing in the sandy alluvial soils of the Guban have very deep root systems compared with those of the Haud and the Central Plateau and are therefore able to withstand more over-grazing, trampling and exposure of the roots by wind erosion, than plants in the Haud or on the Plateau.

(A full bibliography follows at the end of Part IV.)

DIAGRAM 23

MAIN SURFACE ROOTS OF ACACIA TREES IN GUBAN

GED DOBO, LOWER SHEIKH, MAY 1945



ACACIA MISERA VATKE "KHANSA"

ACACIA SOCOTRANA BALF. F. "JERIN"

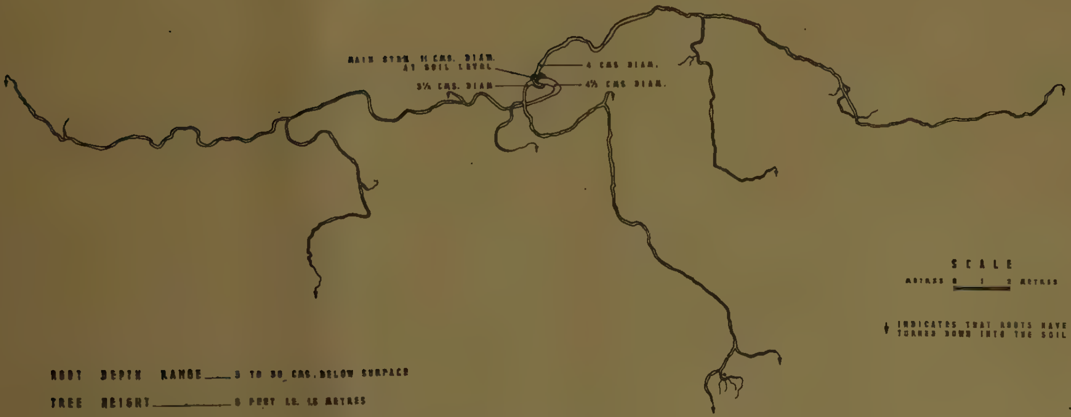
ACACIA SPIROCARPA HOCHST "GURAH"

ACACIA SP. SARMAN JIFJIF

GED DOBO 2-6-1945

DIAGRAM 24

SEMI-DIAGRAMATIC SURFACE VIEW OF MAIN ROOTS



↓ INDICATES THAT ROOTS HAVE TURNED DOWN INTO THE SOIL

ROOT DEPTH RANGE — 3 TO 30 CMS. BELOW SURFACE

TREE HEIGHT — 6 FEET I.E. 1.8 METRES

TREE CANOPY — 13½ FEET I.E. 4 METRES

SOIL — STONY

ACACIA SOCOTRANA BALF. F. "JERIN" VERN.

GED DOBO, LOWER SHEIKH 27th MAY 1945

DIAGRAM 28

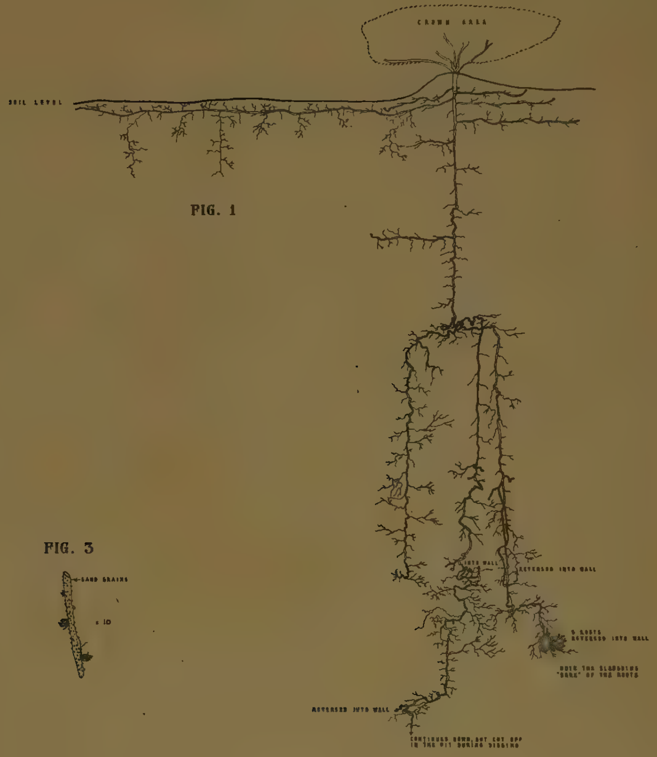

CROWN AREA
SOIL LEVEL
INTO WALL
REVERSED INTO WALL
5 ROOTS REVERSED INTO WALL
NOTE THE SLOUGHING "BARK" OF THE ROOTS
REVERSED INTO WALL
CONTINUES DOWN, BUT CUT OFF IN THE PIT DURING DIGGING

FIG. 1

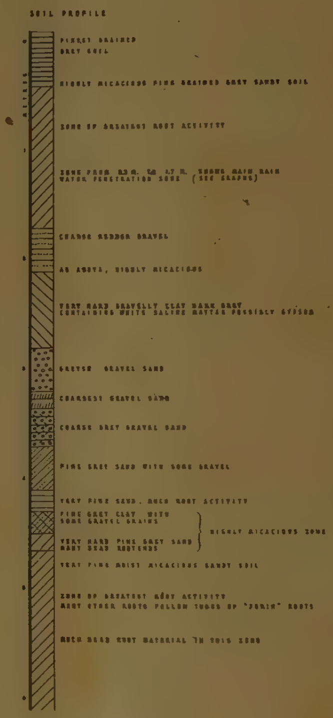

SOIL PROFILE
METRES
0
1
2
3
4
5
6
FINEST GRAINED GREY SOIL
HIGHLY MICACEOUS FINE GRAINED GREY SANDY SOIL
ZONE OF GREATEST ROOT ACTIVITY
ZONE FROM 0.5 M. TO 1.7 M. SHOWS MAIN RAIN WATER PENETRATION ZONE (SEE GRAPHS)
COARSE REDDER GRAVEL
AS ABOVE, HIGHLY MICACEOUS
VERY HARD GRAVELLY CLAY DARK GREY CONTAINING WHITE SALINE MATTER POSSIBLY GYPSUM
GREYISH GRAVEL SAND
COARSEST GRAVEL SAND
COARSE GREY GRAVEL SAND
FINE GREY SAND WITH SOME GRAVEL
VERY FINE SAND, MUCH ROOT ACTIVITY
FINE GREY CLAY WITH SOME GRAVEL GRAINS
VERY HARD FINE GREY SAND MANY DEAD ROOT ENDS
HIGHLY MICACEOUS ZONE
VERY FINE MOIST MICACEOUS SANDY SOIL
ZONE OF GREATEST ROOT ACTIVITY MANY OTHER ROOTS FOLLOW TUBES OF "JERIN" ROOTS
MUCH DEAD ROOT MATERIAL IN THIS ZONE

FIG. 3

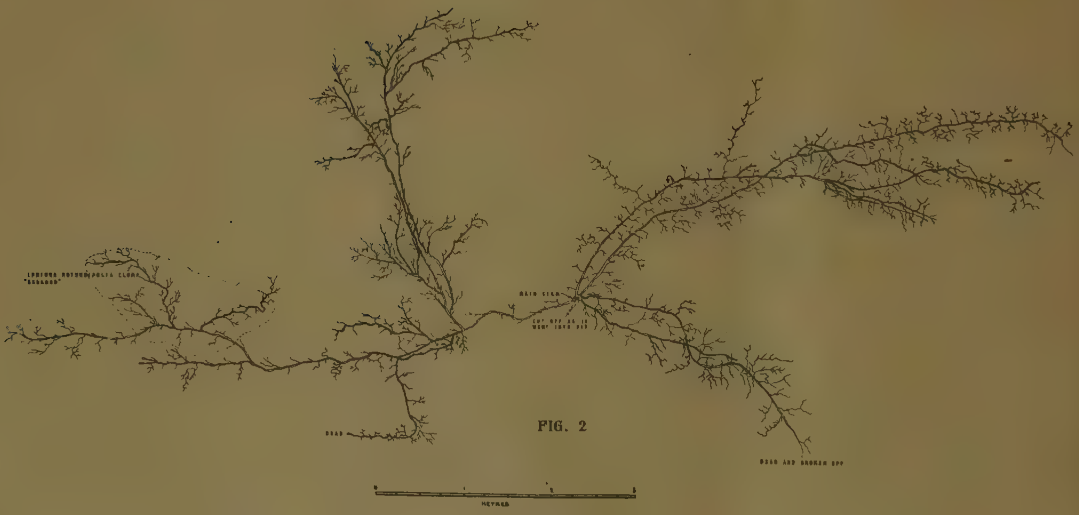
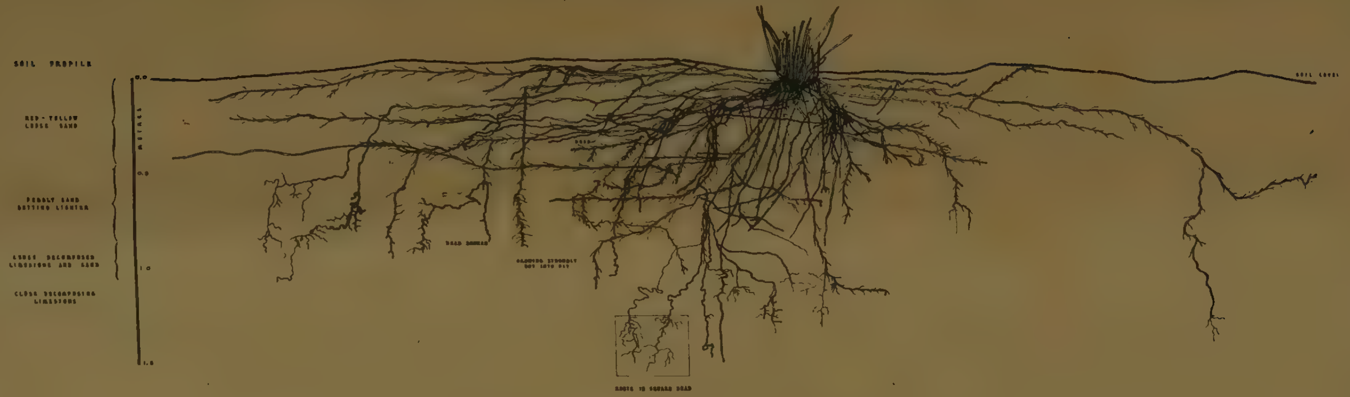


FIG. 2

FIG. 1 – ROOT BISECT
FIG. 2 – DETAILED DIAGRAM OF SURFACE ROOTS
FIG. 3 – ENLARGEMENT OF PART OF ROOT SHOWING BACTERIAL ROOT CLUSTERS

ROOT BISECT OF BLEPHARISPERMUM FRUTICOSUM KLATT AND SCHINTZ "GAHAIT"
ALABLAH BALLEH, 16TH OCTOBER 1945

DIAGRAM 26



ENTADA FLEXUOSA HUTCH. AND DALZ. VERN. "FARADERE"
1ST OCTOBER 1945

DIAGRAM 27

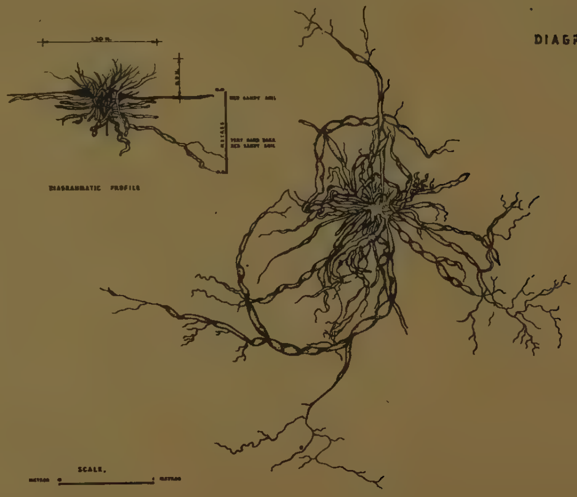


DIAGRAM 26
DIAGRAM 27

PLAN AND DIAGRAMMATIC PROFILES OF ROOT SYSTEM OF ERYTHRINA ROTUNDATO-OBOVATA BAK. F. "YO-OH"

ALABLAH BALLEH IN THE WADERE DISTRICT OF THE HAUD - SOMALIA - 8TH OCTOBER 1945

DIAGRAM 28

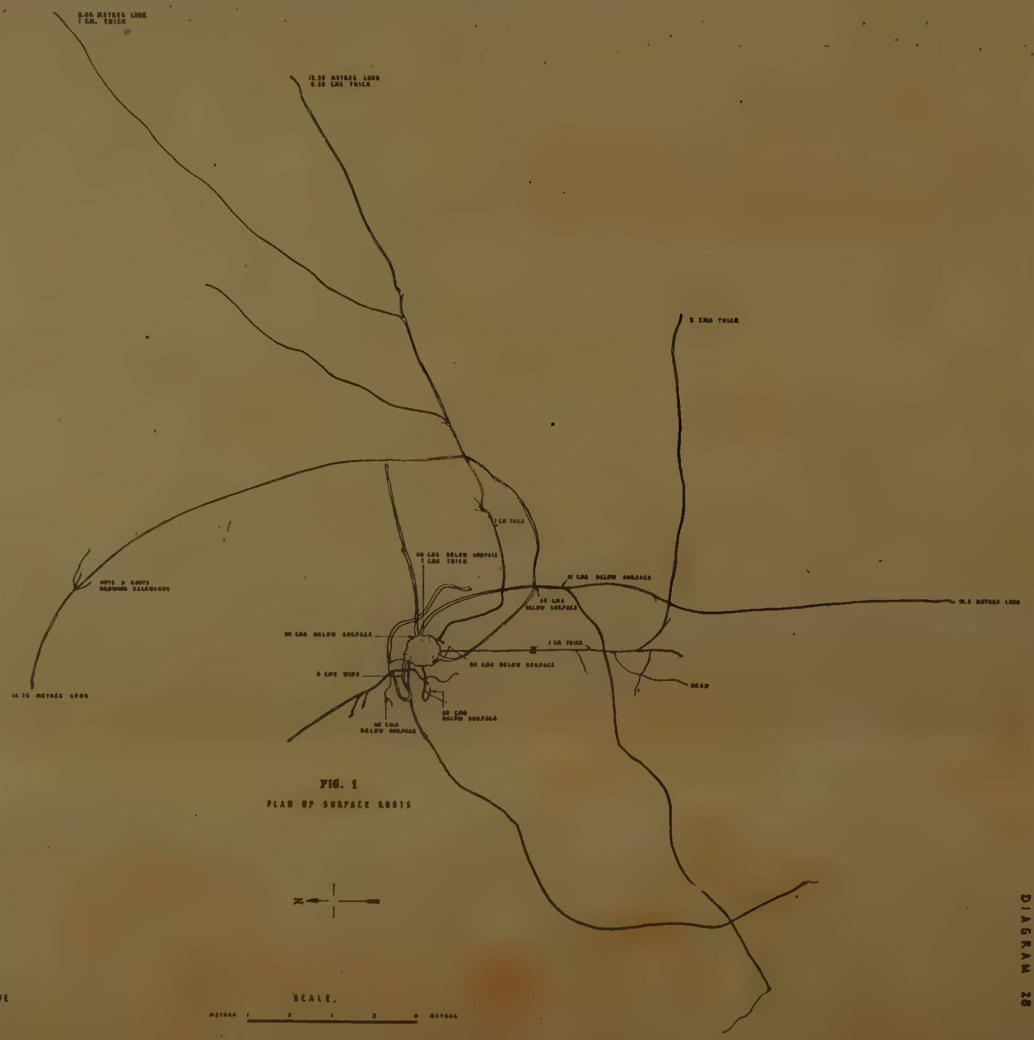


FIG. 1

PLAN OF SURFACE ROOTS

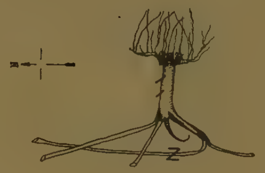


FIG. 2

SEMI-DIAGRAMMATIC PROFILE SHOWING ROOT-STEM RELATIONSHIP IN THE NORTH-SOUTH PLANE

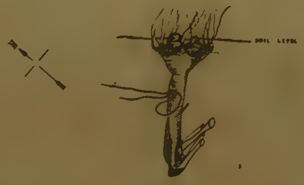


FIG. 3

SEMI-DIAGRAMMATIC PROFILE SHOWING ROOT-STEM RELATIONSHIP IN THE NORTH-EAST-SOUTH-WEST PLANE

DIAGRAM 29

IPHIONA ROTUNDIFOLIA OLIV. AND [redacted] VERN. "GEGABOD"
SILIL TUG, 8th MARCH 1945

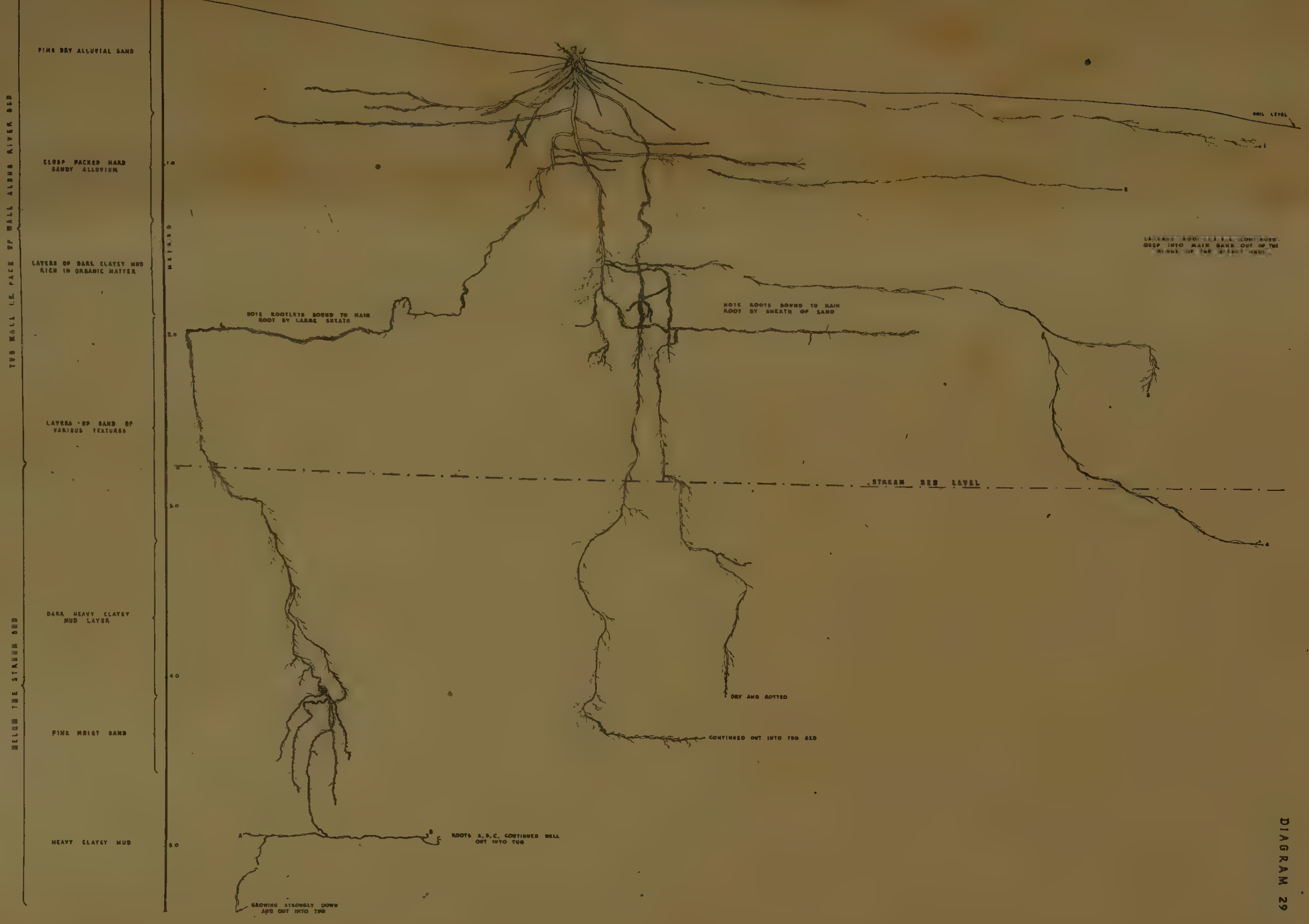
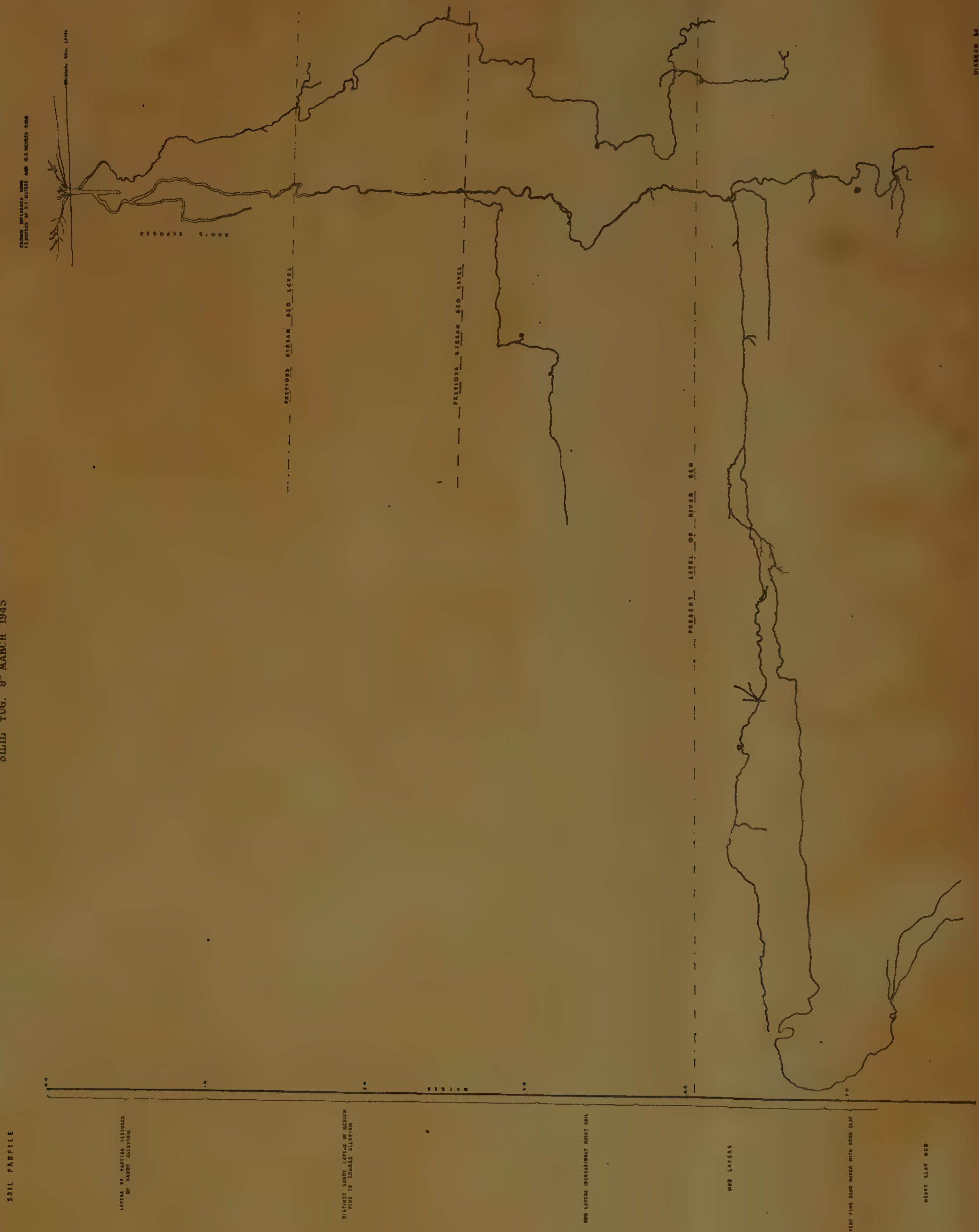

SOIL PROFILE
FINE DRY ALLUVIAL SAND
CLOSE PACKED HARD SANDY ALLUVIUM
LAYERS OF DARK CLAYEY MUD RICH IN ORGANIC MATTER
LAYERS OF SAND OF VARIOUS TEXTURES
DARK HEAVY CLAYEY MUD LAYER
FINE MOIST SAND
HEAVY CLAYEY MUD
THE WALL I.E. FACE OF WALL ALONG RIVER BED
BELOW THE STREAM BED
0.0
1.0
METRES
2.0
3.0
4.0
5.0
SOIL LEVEL
1
2
3
4
LATERAL ROOTS 1, 2, 3, 4, CONTINUED DEEP INTO MAIN BANK OUT OF THE SCOPE OF THE SUBJECT EXCT.
NOTE ROOTLETS BOUND TO MAIN ROOT BY LARGE SHEATH
NOTE ROOTS BOUND TO MAIN ROOT BY SHEATH OF SAND
STREAM BED LEVEL
DRY AND ROTTED
CONTINUED OUT INTO TUG BED
A
B
C
ROOTS A, B, C, CONTINUED WELL OUT INTO TUG
GROWING STRONGLY DOWN AND OUT INTO TUG

DIAGRAM 30

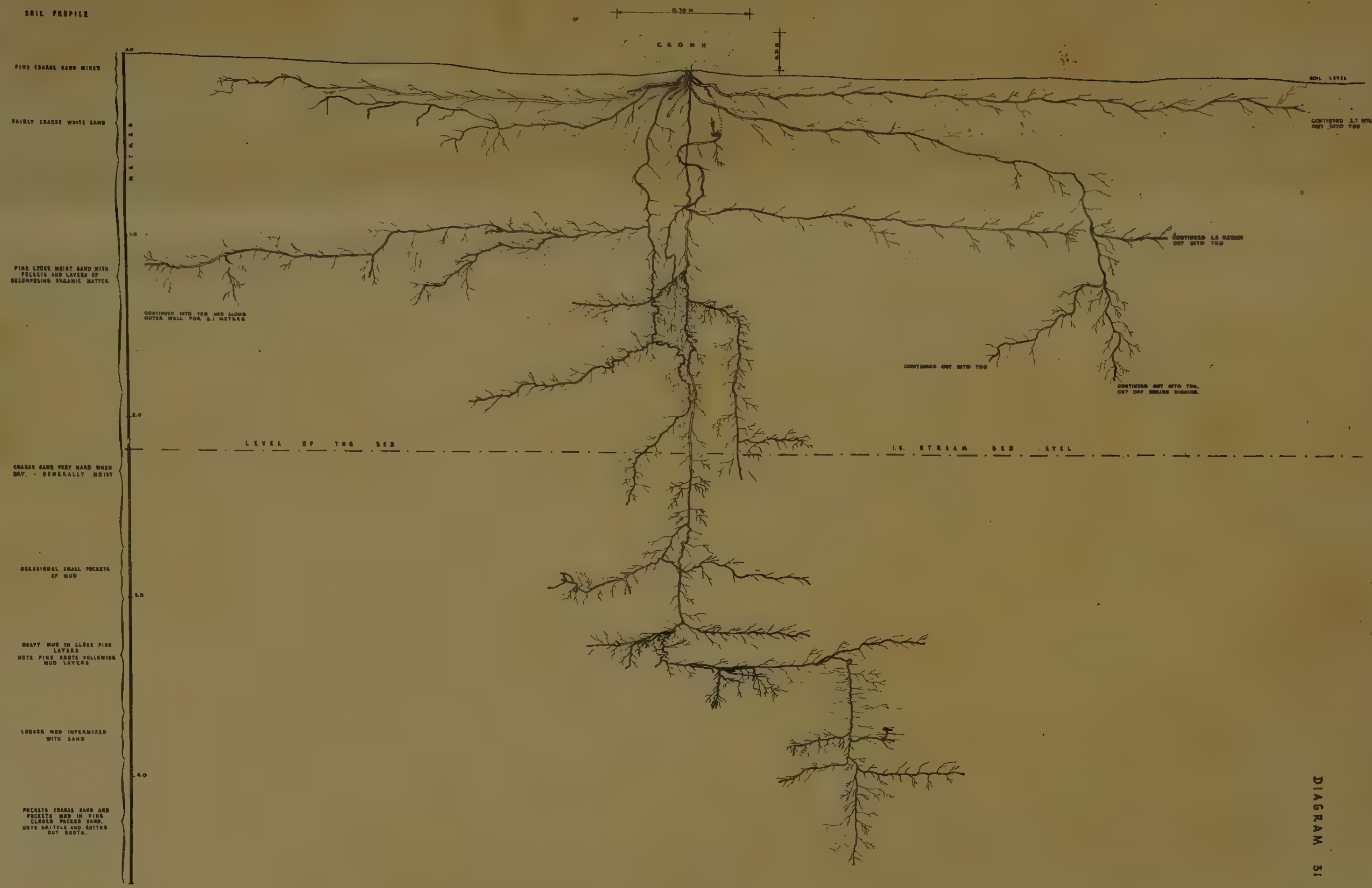

CROWN INFLUENCE LOSS
1.5 METRES BY 3.7 METRES AND 0.5 METRES HIGH
ORIGINAL SOIL LEVEL
ROOTS EXPOSED
PREVIOUS STREAM BED LEVEL
PREVIOUS STREAM BED LEVEL
PRESENT LEVEL OF RIVER BED
DIAGRAM 30
0
1
2
METRES
3
4
5
SOIL PROFILE
LAYERS OF VARYING TEXTURES OF SANDY ALLUVIUM
DISTINCT SANDY LAYERS OF MEDIUM FINE TO COARSE ALLUVIUM
MUD LAYERS INCREASINGLY MOIST SOIL
MUD LAYERS
VERY FINE SAND MIXED WITH SOME CLAY
HEAVY CLAY MUD

SALSOLA FOETIDA DEL. VERN. "GULAN"
SILIL TUG. 9th MARCH 1945

DIAGRAM 31

SECAMONE PUNCTULATA DECNE. VERN. "GESERIAD"

SILIL, 7TH MARCH 1945


SOIL PROFILE
FINE COARSE SAND MIXED
FAIRLY COARSE WHITE SAND
FINE LOOSE MOIST SAND WITH POCKETS AND LAYERS OF DECOMPOSING ORGANIC MATTER
COARSE SAND VERY HARD WHEN DRY. - GENERALLY MOIST
OCCASIONAL SMALL POCKETS OF MUD
HEAVY MUD IN CLOSE FINE LAYERS
NOTE FINE ROOTS FOLLOWING MUD LAYERS
LOOSER MUD INTERMIXED WITH SAND
POCKETS COARSE SAND AND POCKETS MUD IN FINE CLOSED PACKED SAND.
NOTE BRITTLE AND ROTTED OUT ROOTS.
METRES
0.0
1.0
2.0
3.0
4.0
0.70 M
CROWN
SOIL LEVEL
CONTINUED 2.7 MTS. OUT INTO TUG
CONTINUED 1.5 METRES OUT INTO TUG
CONTINUED OUT INTO TUG
CONTINUED OUT INTO TUG, CUT OFF DURING DIGGING.
CONTINUED INTO TUG AND ALONG OUTER WALL FOR 3.1 METRES
LEVEL OF THE BED
I.E. STREAM BED LEVEL

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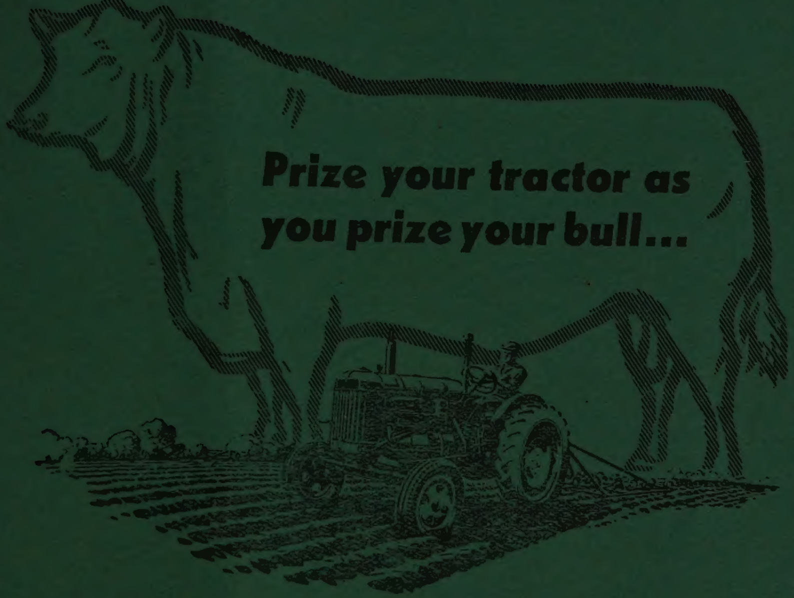

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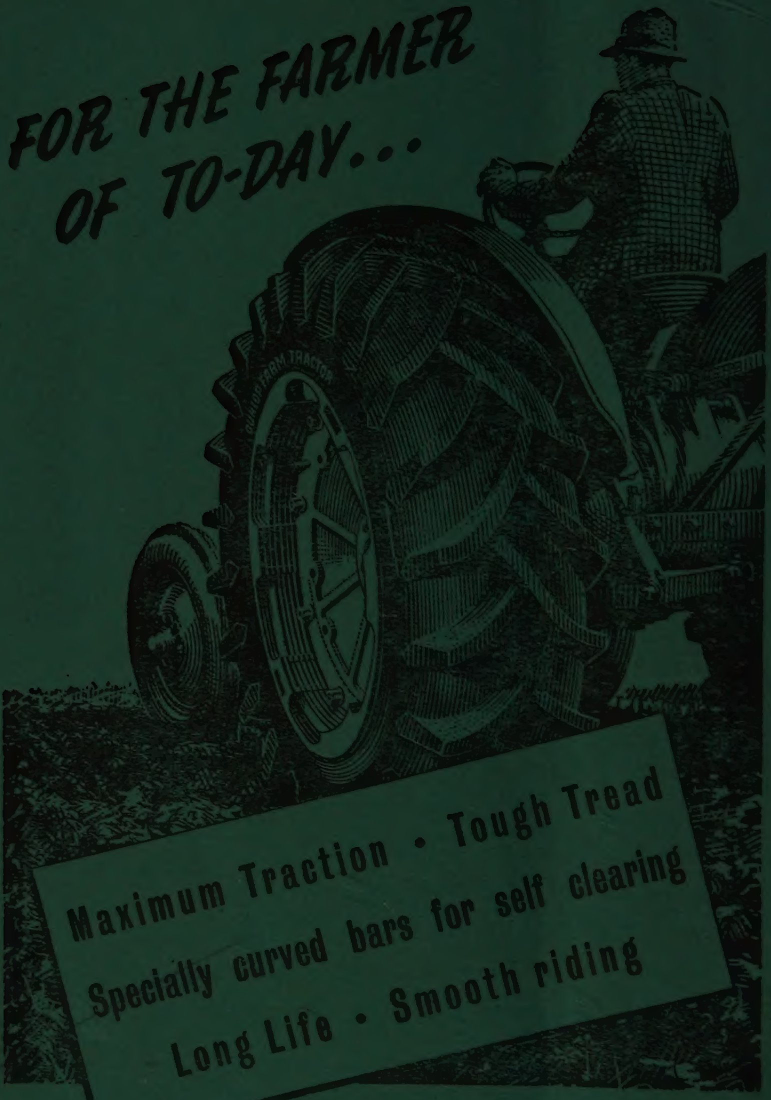

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